No. 3081

United States Circuit Court of Appeals

For the Ninth Circuit

MINERALS SEPARATION, LTD., ET AL,

Appellees,

vs.

BUTTE & SUPERIOR MINING COMPANY,

Appellant.

Transcript of Record

Volume 3

(Pages 657 to 1320, Inclusive)

UPON APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF MONTANA

McKee Ptg. Co., Butte, Mont.

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been removed, it does not describe the thorough aeration of the liquid. Again I miss the duration of the agitation. If this experiment is meant as an experiment of the test tube example in the Froment patent, then I distinctly say it is nothing of the kind. I have often mentioned the difficulty which is experienced by many people that they cannot separate themselves from the knowledge of the present day and put themselves into the condition of the knowledge existing at an earlier time. It is impossible for me to conceive for what purpose this experiment has been introduced, as I cannot think that Dr. Byrnes meant to describe it as a Froment experiment. The purpose of experiment (6) is equally obscure and does not contain any contribution with regard to the Froment patent. Why Dr. Byrnes dissolved two drops of cotton seed oil in ether and poured this solution over 10 grams of ore, I do not know. If he thinks that is a better way of distributing the oil over the surface of the ore, then I disagree, as this mode is not conducive to uniform oiling, and why he afterwards heated the ore thus prepared with 30 grams of water and sulphuric acid, is equally incomprehensible to me. The Froment test tube example is simple. Mix 10 grams of ore with one gram of calcite, add sulphuric acid, then a thin layer of oil, agitate for a second and the concentrates will be on the surface of the liquid in the form of a magma.

As to (7), the two experiments described in this, one

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of which is said to be Froment and I assume the other one an imitation of Froment, I say that neither of them is a Froment, and I further say that the description of a thin layer of oil as a few drops is incorrect and not in accordance with the facts. A thin layer requires at least 1.4cc. of oil, which means, according to the size of the outlet of an ordinary pipette, anything from 49 to 63 drops. I repeat again that there is no warming described in the patent of Froment and there is no warming necessary. As I said before, none of these test tube experiments are in accordance with the test tube example described by Froment, and none of them have any bearing thereon.

On page 165 of Defendant's Record, Dr. Byrnes states that he has

> "repeatedly operated the process of the Froment British patent 12,788 of 1902, using the Hyde slide apparatus to effect the brief agitation and frothing, and using different kinds of oil and widely differing amounts of oil."

There is no description of any apparatus in the Froment patent beyond the agitation of the test tube, and there is no description of any frothing. The use of the slide machine is unwarranted and, what is more, it is impossible to produce the Froment result therewith. I have read the five experiments which Dr. Byrnes describes as having been carried out with widely differing amounts of oil. Before going into the details of

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he description and of the results, I should like to state here that the true test of these experiments is to try with the proportions of the quantities used by Dr. Byrnes, but according to the test tube example described by Froment. If they are in accordance with Froment, then the results which Froment describes must be obtainable by the test tube experiment.

Adjourned to Tuesday, October 29, 1912, at 10:30 in the forenoon, at the same place.

New York, October 29, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Direct-examination continued:

Answer to 34-Q continued: In producing these experiments now, it must not be inferred that they are necessary to show that the experiments of Dr. Byrnes, in which he used the "Hyde slide machine" and the description of which begins on page 165 of Defendant's Record, have nothing to do with the Froment patent. I shall criticise Dr. Byrnes' experiments later on on their own merits. I believe, however, that it will be useful to the Court if I show by a translation of the quantities used by Dr. Byrnes to the corresponding quantities and proportions in which they would be used in the test tube experiments of Froment, the wide difference be-

tween Froment and Byrnes, the impossibility of deriving such quantities from Froment and the impossibility of obtaining Froment's result therewith. The first experiment is described in the second paragraph on page 165 of Defendant's Record. The quantities used by Dr. Byrnes are:

492 grams of ore
.3~~1~~ cc. of cotton seed oil
1 cc. (1.8 gram) of sulphuric acid.

If these quantities are translated into the quantities of the Froment test tube example, they are:

10 grams of ore
0.006 cc. of cotton seed oil
0.02 cc. (0.036 gram) of sulphuric acid.

0.006 cc. of cotton seed oil equals about one-fourth to one-sixth of a drop of oil. We have no means of dealing with such quantities and I was compelled to use in this experiment a drop of oil. One-fourth to one-sixth of a drop of cotton seed oil represents Dr. Byrnes' conception of a thin layer of oil in a 100cc. test tube, which he in his experiments relating to the Froment patent used. 0.036 gram of sulphuric acid used used by Dr. Byrnes represents one-half to one-third of a drop of sulphuric acid. It is equally impossible to convey this quantity into a test tube and it can only be done by diluting the acid with water and thus increasing the volume. No such description is mentioned in Froment and

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it was not necessary, as he deals with quantities which can be handled.

I took 10 grams of defendant's ore, which had been crushed in my presence to 80 mesh, mixed it with 30cc of water, added thereto 0.036 gram of sulphuric acid (which I had to dilute in order to be able to convey it into the test tube), and one drop of cotton seed oil. As I said before, there are no means known of conveying the quantity used in Dr. Byrnes' above mentioned experiment, and I was compelled, therefore, to use six times the quantity of oil that was used by Dr. Byrnes. I agitated them for about one to two seconds, with the following result; practically all the ore was at the bottom, some slimes and oil, which could be observed by its glistening, at the top. (It will be remembered that in the instructions Froment says, that the ore must be de-slimed for his purpose.) I repeated the agitation for about seven seconds in a way which might be really called violent agitation, but the result was the same as before described, namely, absolute failure to produce the Froment phenomenon described in his test tube example, namely, that the whole of the mineral will rise to the top of the liquid and form a magma.

The second example described by Dr. Byrnes and which is contained in the last paragraph on page 165 of Defendant's Record and ending on the next page, has been made with the following quantities:

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492 grams of ore
20 cc of cotton seed oil
1 cc (1.8 grams) of sulphuric acid.

These quantities, when translated into the quantities of the test tube example, are:

10 grams of ore
0.4 cc of cotton seed oil (14 drops)
0.02cc (0.036 gram) of sulphuric acid (⅓ of a drop).

These quantities were mixed, as described in the previous experiment, and the mixture was agitated for two seconds. The result was identical with the one of my previous experiment. Practically all the ore was at the bottom of the liquid, some oil containing some slimes on the top. Even after further vigorous agitation for five seconds the result was not altered.

The next experiment of Dr. Byrnes is identical with the previous one, with the exception that he uses 20cc of Ehrmann's California olive oil instead of cotton seed oil, and my experience was identical with my previously described one, with the exception that I used 0.4cc of Ehrmann's California olive oil instead of 0.4cc of cotton seed oil, and the results were identical with the results of the previous experiment, both after shaking from one to two seconds and after shaking for a further seven seconds.

The next experiment of Dr. Byrnes is identical with the second experiment, with the exception that he used

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20cc. of defendant's "red oil," and my experiment was identical with my second experiment above described, with the exception that I used 0.4cc of oleic acid, and the results were identical with the results of the two previous experiments, both after shaking for one to two seconds and after shaking for a further seven seconds.

The last experiment of the series presented by Dr. Byrnes and described in the last paragraph on page 166 of defendant's Record contains a slight variation in the proportions, namely:

500 grams of ore
10 cc of red oil
1 cc (1.8 grams) of sulphuric acid.

The corresponding proportions used by me in a test tube experiment were:

10 grams of ore
0.02 cc (0.036 gram) of sulphuric acid
0.2 cc of oleic acid.

The experiment was carried out in the same way as the first experiment and the result was the same as described of my other experiments of this series.

The conclusions from these experiments are that it it impossible to produce the Froment result with the proportions between ore, oil and acid which Dr. Byrnes used in the slide machine experiments described on page 165 and 166 of Defendant's Record, and I say delib-

erately that it is impossible with such proportions to produce the Froment result of the test tube example, namely, causing the whole of the mineral to rise instantly to the top of the liquid in the form of a magma. It is obvious and self-evident from the result of these experiments that Dr. Byrnes' experiments cannot be in accordance with and are not the invention revealed in the Froment patent.

I will now return to the experiments of Dr. Byrnes. I have calculated the recovery of zinc obtained in each experiment, the amount of zinc left in the tailings, and I have ascertained the loss if there was any occurring in each experiment. In the first four experiments, the quantity of ore used contained 99.9 grams of zinc.

In Experiment 1, Dr. Byrnes recovered	85.25 grams
The tailings contained	13.25 grams
	98.50 grams,

and there was, therefore, a loss of 1.4 grams.

In Experiment 2, Dr. Byrnes recovered of zinc	101.9 grams
The tailings contained	2.9 grams
	104.8 grams

Dr. Byrnes, therefore, recovered 4.9 grams more than was contained in the original ore. The margin is rather wider than is usually allowed for errors in the analysis.

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In Experiment 3, Dr. Byrnes recovered	97.0 grams
The tailings contained	1.6 grams
	98.6 grams,

and there is, therefore, a loss of 1.3 grams.

In Experiment 4, Dr. Byrnes recovered 27.4 grams. The tailings were not assayed.

There is, therefore, in this experiment a loss of 72.5 grams.

In Experiment 5, the zinc contained in the quantity of the ore used was 101.5 grams.

Dr. Byrnes recovered	95.9 grams
The tailings contained	3.1 grams
	99.0 grams

There was, therefore, a loss of 2.5 grams.

I will recall the fundamental idea on which Froment based his invention. A gas generated in the nascent state will cause minerals moistened by oil to rise to the surface of the liquid. He describes as such gas carbonic acid and he generates it in the nascent state by the action of sulphuric acid on limestone. Metallic carbonates, it may be generally stated, are capable of evolving carbonic acid on addition of sulphuric acid. But the conditions necessary to produce the reaction may vary and do vary widely. The celerity of the re-

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action depends on a number of factors, namely, whether the carbonate is soluble in the medium in which it is exposed to the action of the acid, whether if soluble it is presented in the very finest powder to the action of the acid, whether even if finely powdered the small particles have a crystalline structure or whether they are amorphous, whether they are individual particles or whether they are enclosed within some other substance resisting the action of the acid. All these factors are of great importance and the rapidity or slowness of the generation of carbonic acid will depend on the selection of a suitable carbonate. Rhodochrosite, which is chemically manganese carbonate, is not readily attacked by sulphuric acid and it requires warming when mixed with a liquid before sulphuric acid will generate carbonic acid from it. I have found that in the state in which it is contained in defendant's ore, even if the ore is crushed to an 80 mesh, it is not readily attacked by sulphuric acid at a temperature of 40° Centigrade (104° Fahrenheit), and Dr. Byrnes observed the same fact. He states, on page 159 of Defendant's Record, in Experiment 4.

> "and the mixture was gently heated, whereupon gas was chemically liberated by the action of the acid on the carbonate."

The mixture to which the sulphuric acid had been added consisted of 10 grams of Black Rock ore finely powdered and contained in 30cc of water, to which, as

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described in (4), sulphuric acid had been added. The same fact is described again in Experiment 6, in which 10 grams of oiled ore were mixed with 30 grams of water. 5 grams of sulphuric acid were added to this mixture and

> "the whole was gently heated to cause the sulphuric acid to react on the carbonate in the ore."

And the same fact is described in (7) of this series of Dr. Byrnes' experiments, in which he states,

> "On warming to start the reaction."

Dr. Byrnes represents the experiments made in the slide machine and described on pages165 and 166 of Defendant's Record as experiments falling under the Froment patent. The result must, therefore, be due to the generation of carbonic acid by the action of sulphuric acid on the rhodochrosite contained in defendant's ore, which he used in these experiments. I am sure, from experiments which I made, that scarcely any action of sulphuric acid on the rhodochrosite can have taken place. It is further a fact that, if the whole of the sulphuric acid had been used up in Dr. Byrnes' experiments, it would be utterly inadequate to produce the result which has been described by Froment. 1cc of sulphuric acid represents in weight 1.8 grams, and it is capable to produce 0.8 grams of carbonic acid. 0.8 grams of carbonic acid represents in volume 0.4 of a liter. The solubility of carbonic acid in water of ordinary tempera-

ture is one volume of carbonic acid in one volume of water. Dr. Byrnes used in his experiments 1700cc. equal to 1.7 liter of water, which at ordinary temperature is capable of dissolving practically four times the quantity of carbonic acid which could have been generated if all the sulphuric acid had been consumed. Twice the amount of carbonic acid would have been practically dissolved by the amount of water if the temperature had been 50° Centigrade instead of ordinary temperature or the temperature of 70° Fahrenheit, which is 21° Centigrade, which Dr. Byrnes used. The agitation in the slide machine would assist the solution of the carbonic acid in water considerably and would put it practically out of action for the purpose and the duty which Dr. Byrnes alleges it performed. In the first of his experiments, Dr. Byrnes used a quantity of oil, namely, .3cc (.27 gram), for 492 grams of ore. That is, roughly, 1.1 lb. per short ton of ore. I cannot conceive the reasons which induced Dr. Byrnes to describe this experiment as an experiment conducted according to the Froment patent. It differs in principle, in proportions and in the mode of carrying out absolutely from anything which is revealed in the Froment patent. As a matter of fact, it is nothing but the production of the agitation froth carried out according to the process of the patent in suit, such process being understood to mean an agitation such as will commingle air with a mixture of ore pulp with a quantity of oil such as described in the patent in suit in the presence of a small

ıantity of sulphuric acid. Dr. Byrnes describes in ıis experiment, which he characterizes as a Froment xperiment, that he collected five froths (I will not re- eat again and again that Froment does not obtain a ·oth). I fail to find in the Froment patent anything hich could possibly induce a metallurgist to effect the ecovery of the mineral by five repetitions of the froth roduction experiment. On the contrary, Froment states vice that in one operation the whole of the mineral is emoved from the ore (Froment British Spec., page 2, nes 37, 38, and page 3, lines 4-6):

> "the whole of the copperpyrite will instantly rise to the top of the liquid."
>
> "Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis."

repeat that Experiment 1 is nothing but the performınce of the process of producing the agitation-froth of he patent in suit.

The Experiment 2 differs from 1 that sixty-six times he amount of oil was used therein. The other parts of he mixture, namely, water, acid and ore, are the same ıs in Experiment 1. All the facts which I stated with ·egard to Experiment 1 apply therefore with equal force o this experiment. It can never be considered a Fronent experiment. The quantity of oil in Experiment 2 is :onsiderably larger than the quantity used in Experiment

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1. It amounts to 72 lbs. of oil per short ton of ore. The in appearance and character entirely different from the concentrates produced on the surface of the liquid are both agitation froth of the patent in suit. The oily character of the minerals is clearly visable to the naked eye. I should describe it as a mixture of oil, minerals and air bubbles. My conclusions are the same as derived from the first experiment. The oil quantities are not Froment's quantities; the acid quantities are utterly different from Froment's quantities, and the principle involved is utterly different from Froment's principle. It is the application of an agitation resulting in commingling air with the pulp, oil and ore, which has been for the first time consciously stated in the patent in suit for the purpose of concentrating ores by means of a froth. I need scarcely add that the quantities of oil used in the second experiment render it perfectly useless for manufacturing purposes by reason of the expense for the concentration of ores, even if the concentration were as good as described in this experiment.

The same remarks and criticisms apply equally to the other three experiments.

Experiment No. 4 shows rather exceptional results, as the recovery by three repeated operations, or, as Dr. Byrnes calls it, by three froths, amounted only to 27.4% of the whole zinc contained in the ore. In experiment 5 Dr. Byrnes obtained by the collection of four froths (his term) the recovery of about 95% of the zinc contained in the ore. Dr. Byrnes seems to explain the

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fference in these two results by the fact that in experi-
ent 4 "red oil," or, as he calls it, "impure oleic acid"
as used, whilst in experiment 5 a pure "red oil" had
en used, that means, a "red oil" which contained less
the solid fatty acids, namely stearic and palmitic
id. I have analyzed two specimens of defendant's
eic acid, one marked "Specimen 2 of Defendant's Oleic
cid," and which was received by me, through coun-
l, from Dr. Byrnes as a specimen of the ordinary "red
l" which he had used in his tests, and the other marked
Defendant's Purer Oleic Acid," which was received
me, through counsel, as a specimen received by him
om defendant of the purer "red oil" used by the de-
ndant and by Dr. Byrnes in the experiments described
their testimony. The result of this analysis was
at these two oils are identical in the amount of
lmitic and stearic acid they contain. Both of them
ntain the same quantity of oleic acid and the same
tal quantity of palmitic and stearic acid.

The result of this analysis excludes the reason by
hich Dr. Byrnes seems to explain the difference in re-
lt of recovery according to experiment 4 and of ex-
riment 5, to which might be well added the other
periments.

Adjourned to Wednesday, October 30, 1912, at 10:30
the forenoon, at the same place.

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New York, October 30, 1912.

Met Pursuant to adjournment.

Present—Counsel as before.

Direct-examination continued:

Answer to 34-Q. continued: In the experiment which I carried out in the test tubes, translating the quantities used by Dr. Byrnes for the experiments described on pages 165 and 166 of Defendant's Record into the corresponding test tube quantities, I have stated that, for the experiments described by Dr. Byrnes in the second paragraph and in the last paragraph of page 166 of Defendant's Record, I used oleic acid. I did use oleic acid for the following reasons. Dr. Byrnes states, in the last of the experiments quoted:

> "It should be noted that the 'red oil' used in this test was a special or somewhat purer form of oleic acid than that used in the preceding run, more of the solid fatty acids, stearic and palmitic, having been removed by the maker, Charles T. Perry & Co., rendering it thinner and less viscous, pasty or solid at ordinary temperatures."

I have stated that the analysis of the oil in question proved his conclusions to be erroneous. I would however, have taken this oil for these experiments, if not unfortunately the glass bottle which contained it had been broken on the journey from England to this coun-

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ry. In order to satisfy the criticism and objections which Dr. Byrnes offered with regard to the oil which he calls a more impure oil, I selected for use in this experiment a commercial oleic acid which did not contain as precipitates solid fatty acids, stearic and palmitic acids, at ordinary temperature, and it was free from the objections which Dr. Byrnes seems to attribute the bad concentration results of the first experiments with "red oil."

The analysis which I carried out with the two "red oils" obtained from counsel, as stated before, proves that Dr. Byrnes' explanation of the bad result of concentration of the first experiment with that "red oil" is not borne out by the facts. My explanation is that, in the initial operations, a large quantity of oil may have been removed and that, therefore, in experiments 2, 3 and 5 of this series, proportions between oil and ore were created falling within the proportions revealed in the patent in suit, just as the proportions of Example 1 of the series are the proportions of the patent in suit.

I have calculated the quantities of oil revealed and used in the experiments of Dr. Byrnes, on pages 165 and 166 of Defendant's Record, for a ton of ore, and equally so the lowest quantities of oil which I have found by actual estimation disclosed in Froment, and I state the results in the following table:

Dr. Byrnes' experiments on pages 165 and 166 of Defendant's Record.

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Expt. No. 1, the quantity of oil 1.1 lb. per short ton of ore;
Expts. 2, 3 & 4, quantity of oil 73 lbs. per short ton of ore;
Expt. 5, quantity of oil 36 lbs. per short ton of ore.

Froment British Patent No. 12,778 of 1902.

Smallest quantities of oil 250 lbs. per short ton of ore.

In complainants' patent in suit the quantity of oil "found suitable and economical" is 2 lbs. of oil per short ton of ore. This quantity may be varied, it may be lower or higher, but the amount stated has been in the experience of the patentees a suitable and economical quantity.

The quantities of oil used by Froment and the quantities of oil used by Dr. Byrnes in his experiments 2, 3, 4 and 5 would render any process in which they were used valueless for commercial purposes. Ore concentration carried out, even with much smaller quantities, for instance, with the quantities which Cattermole described in his specification, were fatal to the commercial success, even if otherwise producing satisfactory results. Figures will be the best illustration. If the price of oleic acid were 5 cts. a pound, the cost involved for the treatment of one short ton of ore would be, for the quantities which Dr. Byrnes used,

For Experiments, 2, 3 and 4,	$3.65
For Experiment 5,	$1.80
For Froment,	$12.50
For Complainant's patent in suit,	.10

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is true that in processes such as Froment's or as de-
ribed in Experiments 2, 3 and 4 of Dr. Byrnes, part
the oil would be recovered, but such recovery would
volve expense. Furthermore, only part of the oil
ntained in the concentrates can be recovered as such.
considerable amount remains in the concentrates. But
ncentrates with such amount of oil would be unsale-
le and this remnant has to be removed by chemical
gents, which again is a costly operation.

Adjourned to Thursday, October 31, 1912, at 10:30
the forenoon, at the same place.

New York, October 31, 1912.

Met Pursuant to adjournment.

Present—Counsel as before.

irect-examination continued:

Answer to 34-Q. continued: I have stated that the oil
hich is left in concentrates cannot be all removed
herefrom, even by high hydraulic pressure or by filter
resses. A considerable amount remains. I have esti-
nated the amount, that is, I have ascertained the
mount by analysis, and I have found that, after ex-
osing a mixture of oil and concentrates to the high-
est pressure that I could produce, which pressure was
far in excess of the pressure obtainable by filter presses,
the amount of oil left in the concentrates to be 9% in

weight of the concentrate. It is possible to remove such quantity by after treatment with chemical agents, if the oils belong to the class of vegetable or animal oils. In such case, a treatment with caustic alkalis will dissolve them, but naturally there is the cost of the chemical agent and the cost and working expense of this treatment to be added to the first expense. The oil is obtained in a form commonly called soap, and to recover it for the purpose of use in ore concentration, it must be treated with acids. A soap is like a carbonate, a salt. That means, the combination of an acid with a metallic base. In carbonates the acid is carbonic acid. In soaps the acid is a fatty acid like oleic acid. By the action of the stronger acid on soap, the metallic base contained in soap combines with the stronger acid and the fatty acid is liberated in this process. This operation again involves cost for chemical agents and additional working expenses. If fatty oils, such as olive oil or cotton seed oil, have been used, it is impossible to recover these by the treatment with alkali. They would be decomposed and converted into fatty acids by such treatment. The only treatment would be to extract them with solvents, which is quite out of the range of a process like ore concentration. The cost would be enormous and the result would be again that instead of losing the oil, a portion of the solvent would be lost. What is more, the solvents suitable for the purpose are of a highly inflammable character and would be dangerous to use. If heavy mineral oils

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main in the concentrates, they cannot be removed by ustic soda in any form and they have to remain in id are a loss. They could be removed by extraction ith other solvents, but that process is quite out of the iestion and impossible, both on the consideration of ›st, which would be enormous, and owing to the in- ammability and danger of the extracting solvents hich would have to be used. It is a fact that any ocess of ore concentration, which results in the leav- ig of considerable quantities of oil in the concentrate, ill be highly costly, even if part of the oil can be re- ›vered by filter presses or hydraulic presses.

I have stated what, in my view, is the true reading f the Froment specification, No. 12,778 of 1902, and hat is revealed therein. Dr. Byrnes has not produced single experiment which can be called an experiment ruly carried out according to the Froment patent. His est tube experiments have nothing whatever to do with t. His experiments on pages 165 and 166 have noth- ng whatever to do with it. I have not repeated them. have not considered it wise to chase these hares which iave been pushed into our road to detract attention rom the real issue of this case, to complicate its sim- ›le issues and to confuse them. Dr. Byrnes states hat he has produced in the first experiment of the series froth of concentrates. There is nothing surprising in his. He used the process which for the first time in he history of ore concentration was revealed in the ›atent in suit, and he practically used the quantities

which are described therein as being suitable and eco-nomical. He commingled, by brisk agitation, air, or and traces of oil, traces so small that they cannot b translated into the test tube experiments of Fromen He produced the agitation froth. He did not lear that from Froment, but he learned it from the patent i suit. He then used the same process with very much larger quantities of oil and states again that he obtained a froth. There may be what is popularly called a froth, but this froth differs in characteristic qualities from the froth produced with the quantities of oil described by the patentees of the patent in suit as suitable and eco-nomical. It contains large quantities of oil which are quite visible and can even be detected by the touch. The appearance of the minerals is changed. They have a dull look and lack the metallic luster of the minerals. The agitation froth produced with the quantities of oil which the patent in suit informs you are suitable, does not disclose the presence of any oil. The faint traces of oil which must be there are absolutely invisible and only a careful chemical analysis can show their pres-ence. To the touch the concentrates thus obtained are the same as the ordinary mineral which had never been treated with any oil. I cannot understand why Dr. Byrnes produced these experiments. He only proves that he can produce, with much larger quantities of oil than are considered economical by the patent in suit, a froth, but at the same time he proves that the quantities recommended as economical in the patent in suit are

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conomical. It frequently occurs in patent litigation hat a defendant will make an untenable defense by al-ging that he produces a result by different quantities, ometimes by much larger quantities, but, of course, uch a defnse must always fail. It is no defense to use he essence of the invention and produce only a result which increases the cost of production in such an enormous way as the cost would be increased if quantities of oil were used such as described in experiments 2, 3, 4 and 5 of the series described in Defendant's Record, pages 165 and 166. I have stated my views on the Froment patent and on the Froment instructions fully, and I need only repeat once more that there is nothing contained therein which would enable anybody to produce the agitation froth of the patent in suit, and furthermore, that there is nothing contained therein which might lead an investigator even in the direction of the invention of the patent in suit.

By Mr. Scott: That part of the preceding answer beginning with the words "I have not repeated" and extending to the words "confused them;" that part of the answer beginning with the words "It frequently occurs" and extending through the words "pages 165 and 166," are objected to as being merely argumentative and embodying no statements of fact or of opinion upon any matter concerning which the witness is qualified to testify, or would be competent to testify in any event.

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35-Q. I call your attention to the statement of Dr. Byrnes appearing in Defendant's Record on page 170, referring to the Froment patent or patents, as follows.

> "Froment, as I have noted, confines his description to the process and its principles, leaving the type of agitator to be determined by the user. In his test tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oily agent also thoroughly aerates the mixture, the fine bubbles of selves to the oiled particles, acting with the chemically-evolved gas to float them."

What have you to say to this statement?

A. The first sentence of this quotation is utterly wrong in the main statements, and it is only true in one fact, namely that Froment describes some principles. There is no process described, only a test tube example, and as for the fact that he leaves the type of agitator to be determined by the user, that is only a wild flight of imagination. I said there is no process described, and the word "agitator," as referring to the commercial process, does not occur in the specification.

The second sentence is not correct. The British patent states that a mixture of ore, oil in substantial quantities, limestone, water and sulphuric acid is to be agitated for a brief space, and further on says:

> "Only a few seconds were necessary for completely separating the sulphide of copper from the

P. 680, L. 11, after " of " insert " air distributed throug[h]out it, and attaching them-"

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rest of the gangue in which no single trace of copper could be discovered by analysis."

The Italian patent makes the same statements, except that it says, "a second," instead of "a brief space." There is not a single word contained in the Froment patents referring to aeration, and what is more, I have proved definitely that it is impossible to produce aeration according to the test tube experiments described by Froment. If Froment had had any conception of aeration, he certainly would have described it. It is not the case that the mineral particles are floated by air. They are floated by the carbonic acid generated in the nascent state in the mixture. This is the whole of Froment's disclosure, and this is all that results from testing his disclosures.

36-Q. Have you tested the Cattermole process as applied to Defendant's ore, and, if so, what have you done?

A. I have tested the Catermole process as applied to Defendant's ore, and I have carried out three experiments with regard to it.

1. I used 400 grams of Defendant's ore which had been crushed in my presence to 80 mesh, and make a pulp with 1500cc. of water containing 0.25% of sulphuric acid. To this pulp I added 7.3 grams of oleic acid, which corresponds to 6% of oleic acid on the zinc sulphide content of the ore, and 1.8% on the ore. The whole mixture was contained in a cone mixer or Gab-

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bett and was agitated for ten minutes. It was then, whilst being agitated, emptied out into a classifier in which an upcurrent of water was maintained. The slimes separated in the overflow, whilst the granules fell into a bottle which was fixed at the bottom of the classifier. After the contents of the cone mixer had been completely emptied out and treated in the classifier, the body was withdrawn and the granules filled in a to bottle, which I marked "Cattermole Granules 1."

2. 500 grams of Defendant's ore, the same as described in experiment 1, were made into a pulp with 1500cc. of water containing .25% of sulphuric acid, and 9 grams of oleic acid (6% on the zinc sulphide content of the ore, and 1.8% on the ore) were added thereto. The whole was agitated for ten minutes in the same cone mixer. It was then introduced in the same manner as described in experiment 1 into the classifier. The granules thus obtained were put back into the cone mixer and the same quantity of water containing 0.25% of sulphuric acid was added to them, and the mixture of water and granules was agitated for ten hours. The granules were then collected in a classifier, as before described. They were filled into a bottle, which I marked "Cattermole Granules 2."

3. 400 grams of the same ore were mixed with 1500cc. of water containing 0.5% of sulphuric acid, and 8½ grams of oleic acid (7% on the zinc sulphide content of the ore) were added. The mixture was agitated

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in the cone mixer for ten minutes and the granules were then separated in the classifier, as before described. The granules thus obtained were put back into the cone mixer and the same quantity of water was added as was originally used. The baffles were then removed and the mixture was agitated for nine and a half hours. The granules were then collected in the same way as before described in a classifier, and a number of the larger ones filled into a bottle, which is marked "Cattermole Granules 3." This experiment was carried out according to the alternate method given on page 3, line 46, of the Cattermole patent:

> "With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral."

The mode of preparing the specimen "Cattermole Granules 1," is in accordance with the process which would be worked on a manufacturing scale. Experiments 2 and 3 were carried out with the intention of securing very hard and lasting granules to be used as exhibits, and for this purpose the rolling was continued for nine and a half to ten hours. These latter two experiments are not intended to represent the working of the process as carried out in manufacture.

The three specimens produced by the witness are offered in evidence and marked, respectively:

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"Complainants' Exhibit, Cattermole Granules 1;"

"Complainants' Exhibit, Cattermole Granules 2;" and,

"Complainants' Exhibit, Cattermole Granules 3."

37-Q. Please now give consideration to the testimony of Dr. Byrnes relative to the patent in suit as appearing in his answer to Q-4., pages 110 et seq., of Defendant's Record, and again at pages 167 et seq. of Defendant's Record, making such explanation of your own knowledge of the same subject matter as may clear up the matters referred to.

A. It is true that the patent in suit makes use of the well-known property of minerals that they have an affinity for oils, whilst the gangue practically repels the oils. It has been stated in this evidence that this fact is as old as at least Herodotus. Anyhow, it was clearly established in Haynes' specification applied for in 1860, and since then a number of attempts have been made to solve the difficult problem of ore concentration by this method. They have all failed, although two of them, namely, Elmore and Cattermole, have been practically used. They disappeared as soon as the new invention which forms the subject matter of the patent in suit, was made. The patent in suit was the final solution of a problem to which, as the number of patents offered by the defendant proves, a great

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many inventors had applied their ingenuity, their energy and time and labor, and had been unable to accomplish the result. It happens frequently so with great inventions. The results are not obtained suddenly. Very often a large number of years pass by, every year containing a contribution which remains sterile, until finally the right way is found and the world enriched thereby. I need only mention the Tungsten filament. Efforts of very great men have been directed for over thirty years to make a metallic filament of tungsten. All kinds of methods were used, but the results were futile. Only in 1905 the problem was solved and the carbon filaments, which formerly were the only ones used, practically disappeared altogether. The arrival of the tungsten filament signified great economical progress. In the same way, the arrival of the process of the patent in suit signified great economical progress in the mining industry. Inventions are scarcely ever revelations of new laws. Such an invention is an event to be remembered. In nearly all inventions, even those of the greatest importance, the old methods are used and new ~~fact~~ facts established thereby, which are beneficial to the community. Wireless telegraphy depends on the production of Hertzian waves discovered by the great successor to Prof. Clausius at Bonn. Marconi only found a receiver for these waves. But is this invention less great, less beneficial and less important because Marconi used the Hertzian waves? Herodotus, or, to mention the later inventor,

Haynes, found the preferential affinity of minerals for oils. Carrie Everson discovered that that preferential affinity was rendered more valuable and more pronounced if acid was present in an ore pulp. The gangue thereby was prevented from any attachment to the oil. But does that take away from the merit of the patentees of the patent in suit? Does it do away with the fact that they enriched the world with a new, valuable and greatly successful process for ore concentration, which many had attempted before, but which none had succeeded in?

Dr. Byrnes then continues his description of the document. He mentions for reference the Cattermole patents contained in the patent in suit, and then states the invention, and recites the factors quoted in the patent as assisting the invention. As to (1), the statement of the patentees is quite correct. The addition of acid is not for the purpose of generating a gas. It is simply to prevent the gangue from being coated with the oily substance. And the further statement that

> "the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present,"

is also true, as I have experimentally proved. An ore containing zinc sulphide and galena was subjected to the action of sulphuric acid of a concentration such as specified, for some time, and no zinc was found in the

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olution. If the acid had acted on the zinc sulphide, nc would have been discovered in the acid solution. ead sulphide or galena cannot be attacked by sulhuric acid under such conditions; that is a well-known iemical fact.

Adjourned to Friday, November 1, 1912, at 10:30 in e forenoon, at the same place.

New York, November 1, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

irect-examination continued:

Answer to 37-Q. continued: Dr. Byrnes continues the enumeration of the conditions which assist in e realization of the discovery, warming of the mixre of the pulp, fine pulverization of the ore and the ct to which the patentees specially draw attention at the slime mineral most readily generates scum d rises to the surface. Dr. Byrnes includes within e number of factors or conditions which assist this iall amount of oil in coating the metalliferous mat- and forming a froth, the statements (4) and (5) page 111, that the proportion of mineral which oats in the form of a froth varies considerably with fferent ores, and with different oily substances. This really a warning that it is impossible to describe in

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a document such as a patent specification the details of a process which is capable of being carried out with every one of the innumerable ores in existence. The patentees only can give examples and the essence of the invention, but, as they say, a simple preliminary test, now the facts are known and the new process described, will give you all the information which is required. Dr. Byrnes continues his description and refers to a specific example contained in the specification, but he has here overlooked the important statement:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

This statement is of significance. Even at the time when the inventors could have only a comparatively small experience, they found the proportion of oil in quantities of 0.1 per cent, to one hundred parts of ore suitable and economical. In the number of years which have passed since the filing of this specification, this experience has been confirmed, and proves the power of exact and careful observation of the patentees. In the description of this example, the patentees also called attention to the fact that the power of flotation of the froth is mainly due to the inclusion of air bubbles introduced by the agitation. That is quite correct. In the former attempts, it was the reduced specific gravity

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of a mixture of large quantities of oils with minerals, sometimes assisted by the inclusion of air or gas bubbles, to which the flotation was due. These were the oil buoyancy flotation processes. In the agitation froth process, the oil, although specifically lighter than water, is present in such small quantities, in quantities which I called before infinitesimal as compared with the quantities of oil used formerly for flotation processes, and infinitesimal as compared with the quantity of mineral which they have to coat, that it scarcely plays any part in the flotation of the minerals. The flotation of the minerals is mainly due to the inclusion of air bubbles.

Dr. Byrnes continues the description of the process of the patent in suit, showing how the froth can be removed, and then describes that part of the specification which forms the subject matter of two separate patents. He explains the drawings contained on Sheets 1 and 2. I find on page 115 the statement, of which I said he had overlooked it, namely:

> "an amount of oleic acid constituting 0.1 per cent. of the ore has been found suitable and economical for effecting the flotation, but that smaller amounts may be used."

The patentees say that the amount of 0.1 per cent. of oleic acid in proportion to the ore is suitable and economical

> "to effect the flotation of the mineral in the form of froth."

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The way Dr. Byrnes explained this passage might have been misunderstood because he does not say what kind of flotation the patentees refer to, whereas the patentees specifically say, as above quoted, that a suitable and economical proportion "to effect the flotation of the mineral in the form of froth" may be under 0.1 per cent., but that 0.1 per cent. has been found "suitable and economical." I may add that later on in his deposition Dr. Byrnes appears to have forgotten that the patentees found the proportion of 0.1 per cent. of oil "suitable and economical."

Dr. Byrnes' description of the claims is inaccurate, but as the claims themselves are clear, it is not necessary for me to comment on it, particularly as Dr. Chandler has heretofore fully explained them (Complainants' Record, pages 95-100), and Dr. Byrnes does not criticise Dr. Chandler's explanation.

Dr. Byrnes has overlooked the passage on page 2, lines 40-45 of the patent in suit, as follows:

> "The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied; but, generally speaking, the froth will separate the slime mineral while the larger particles are recovered by the latter method."

This statement is very important, as it foreshadows the possibility of a grinding of the ore which would render unnecessary the supplementary treatment of the

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ilings described in the patent remaining at the bottom of the spitzkasten. This forecast has been realized the practical working of the agitation-froth process. he grinding of the ore is carried out in such manner iat practically the whole of the mineral is recovered ierefrom by the agitation-froth process and no other eatment is required for the tailings; they are left ean. This statement is further important in this espect. By no other practical process, with the exeption of Cattermole, slimes could be treated. In the rocess of the patent in suit, not only can slimes be eated, but the presence of slimes is highly beneficial.

In Dr. Byrnes' answer to Q-4., which I have just onsidered, I think that, with the exception of a few missions, to which I have called attention, Dr. Byrnes as given a fair explanation of the patent in suit. It s not enthusiastic, but, of course, it could not be exected to be enthusiastic.

It is a suitable place here to give my experience of he working of the patent and to describe such experinents which will be of assistance in showing that the tatements made in the patent are correct. I have een the process carried out several times in the plant it the Works of Minerals Separation, Limited, in London. This plant is capable of treating fifty tons of ore i day of twenty-four hours. It is practically the same is that shown in the drawings "Complainants' Exhibit, King John's Court Standard Plant," with the exception that another spitzkasten has been added in front

of the agitating box marked 3, so that there are six spitzkasten, instead of the five shown in the drawings, and that the deflector F was not present. I saw on the spitzkasten large quantities of the froth, which I have characterized before, sometimes three or four inches deep. I have also made numerous tests in the slide machine and in the cone mixer or Gabbett, and I have used for these tests different ores and different oils. I usually succeeded with the quantity of oil, namely, 0.1 per cent., which is recommended in the patent as "suitable and economical." In one instance I found the addition of .025 per cent. to 1 per cent., making a total of .125 per cent., was necessary for the production of a good froth. This was with palm oil. With linseed oil I got the best result with .2 per cent.

I tested also the statement that the power of flotation of the mineral as a froth is due to the inclusion of air bubbles introduced by the agitation. The way to determine the accuracy of this statement is very simple. The gases contained in the froth are collected in a bottle and are then subjected to gas analysis. A suggestion has been made by the defense that the gas which causes the formation of the froth was carbonic acid and not air. In order to prove finally and definitely whether air or carbonic acid is the agent which effects the formation of the froth, I selected the conditions carefully in such way that I was bound to find the maximum amount of carbonic acid which could participate in the formation of a froth. I collected, in

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xperiments which were made with the fifty-ton plant the works of Minerals Separation, Ltd., the gases om the froth appearing on the first spitzkasten, here, if there is any carbonic acid formed at all, most it must collect. In one test the gases collected from e froth resulting from the treatment of an American opper ore showed 98.7 per cent. of air and 1.3 per cent. f carbonic acid. No acid had been used in the treatent of this ore and the 1.3 per cent. of carbonic acid ust have been obtained from the atmosphere. In nother experiment, in which Broken Hill tailings were ubmitted to the process of the patent in suit, 96% f air was found and 4% of carbonic acid. A third ample of gas, which was collected at a different time ut from the same ore, namely, the American copper re, referred to in the description of my first test howed on analysis 98.8% of air and 1.2% of carbonic cid. It will be remembered that no acid had been sed in this process. Carbonic acid is always present small traces in the atmosphere and more so in places here illuminating gas is continuously used, like in the Vorks of Minerals Separation, Ltd. I made further number of gas analyses of gases collected from froths hich were obtained according to the process of the atent in suit in the slide machine. The narrow connes of this machine would result in showing the tmost quantities of carbonic acid which could be resent in any froth. I used a sample of defendant's re which had been treated with acid for eighteen

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hours for the purpose of showing that none of the values had been attacked thereby. The treatment was as follows: 400 grams of defendant's ore, crushed in my presence, were made into a pulp with 1000cc of water, and 9 grams of sulphuric acid were gradually added thereto in quantities of one gram at a time. Then the mixture was allowed to stand for eighteen hours. The ore was collected on a filter, washed thoroughly until neutral, and was then used for the production of a froth according to the patent in suit. The acid added was in the ratio of 10 lbs. per ton of ore. The analysis of the gas revealed the presence of 97.1% of air and of 2.9% of carbonic acid. In another experiment I used the ore marked "Defendant's Feed to Flotation Plant." The froth was produced without the addition of acid and the gas collected from it consisted of 100% of air. No carbonic acid was found. Another sample of gas collected from a froth produced by the process of the patent in suit from the ore marked "Defendant's Feed to Flotation Plant," in which production sulphuric acid had been used with a ratio of 10 lbs. to the ton of ore, showed as a result of analysis the presence of 90.7% of air and 9.3% of carbonic acid. Another sample of gas collected from the froth produced from a French ore in the presence of sulphuric acid (ratio 10 lbs. of acid per ton of ore), showed on analysis 98.8% of air and 1.2% of carbonic acid. I also collected a sample of gas from a froth pro-

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uced according to the process of the patent in uit from a San Francisco del Oro ore, in the presence of sulphuric acid (ratio 60 lbs. of acid per ton f ore). This ore is distinguished by the fact that contains from 4 to 5 per cent. of limestone. The analysis of the gas showed the presence of 77.5% of air nd 22.5% of carbon dioxide.

It is clear from these analysis that the statement of he patentees is perfectly correct, that it is even correct n the abnormal circumstances which occur in the San Francisco del Oro ore, which contains an extraordinary amount of limestone, and, therefore an xtraordinary opportunity for the generation of caronic acid. It will be noticed that in this experiment added six times the amount of acid that was used n the other experiments. It was made by me beause I wanted to find out the largest quantity of arbonic acid which could be obtained in the gases resent in the froth. All the experiments were made at a temperature of 55 degrees Centigrade, so that would have as much carbonic acid as possible in he gaseous form and not in solution in the water. Carbonic acid is soluble in water at ordinary temperatures in the ratio of one volume of carbonic acid to one volume of water. At 55 degrees Centigrade (131 degrees Fahrenheit), the solubility of carbonic acid gas in water is at the ratio of less than half a volume to one volume of water, and at this temperature, therefore, a much larger quantity of carbonic

acid can be in gaseous form than at ordinary temperatures.

I repeat that the statement of the patentees that the froth derives.

> "its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation"

is perfectly correct. I have explained before that, in my view, the word "mainly" refers to the carrying power of air as contrasted with the carrying power of the small quantity of oil present. It might be said that the gas contained in the froth consisted mainly of air and some traces of other gases. But the statement is correct, whichever explanation might be preferred.

My examination of the patent, which I have made as thoroughly as possible, has shown me that the patent contains a valuable invention, that the invention is fully described and does not offer any difficulties in its performance, and that the facts stated are accurate. I can quite understand the remarkable practical results from this invention which are revealed by the testimony.

Adjourned to Saturday, November 2, 1912, at 10:30 in the forenoon, at the same place.

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Met pursuant to adjournment.

Present—Counsel as before.

)irect-examination continued:

Answer to 37-Q. continued: Dr. Byrnes says, on 'age 167, that he has made some tests of the appar-tus shown in Figure 1 of the patent in suit. I have een this apparatus, marked "Defendant's Exhibit, ıpparatus of Patent in Suit." It does not contain ã one mixer. It has a copper vessel of the same general hape indicated by the diagram Figure 1 of the patent ı suit and it has a revolving cone, such as is indicated ı Figure 1. It is not a cone mixer because it has o baffles for breaking up and mixing the fluid. Dr. 3yrnes even calls it a "cone mixer." He apparently oes not know a cone mixer. The cone mixer in 1905 vas a well-known patented apparatus for mixing luids and semi-fluids. It is disclosed in United States patent No. 444,345, issued January 6, 1891, to E. R. Gabbett, assignor of one-half to Boulton, Hay-vood & Boulton. This patent also says that patents ave been obtained for this invention in Great Britain, 3elgium and France. I have also seen the British atent No. 840 of 1889, and have read it and find that t does correspond with the United States patent, which have also read. Messrs. Boulton, Haywood & Boul-on were probably the surviving members of the well-nown firm of Burt, Boulton & Haywood, to whom he British patent was issued jointly with E. R. Gab-

bett, the inventor. As I have said before, I was familiar with this cone mixer before 1905. I was familiar with it in the form of a cylindrical vessel having stationary baffles, although the Gabbett patents say that the vessel may be rectangular and the baffles would not then be necessary, or that the cone may have its direction of rotation "reversed after any desired intervals of time" (British patent, page 3, line 30; U. S. patent, page 2, lines 18, 19). If, therefore, the cone mixer in cylindrical form is to be used without baffles, it must have its direction of rotation reversed at desired intervals. If it is rotated continuously in one direction, you must have baffles that stand still while the cone rotates.

The cone mixer is diagrammatically shown in Figure 1 of the patent in suit and in the patent in suit it is particularly described as a "cone mixer" (Spec., page 1, line 84). It is also diagrammatically shown in the Cattermole patent No. 777,273, and there the cone mixers diagrammatically shown are merely described as "mixing vessels" (Cattermole Spec., page 1, line 82). It is also diagrammatically shown, in Cattermole patent No. 763,259, issued June 21, 1904, and in Cattermole patent No. 763,260, also issued June 21, 1904, and in both these patents the cone mixers diagrammatically shown are described as "mixing vessels." These three prior patents give substantially the same diagrammatic indication of the well-known cone mixer as in Figure 1 of the patent in suit. The cone

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mixer is shown in "Complainants' Exhibit, Young Advertisement A" in substantially the same way. The necessary baffles of the practical working apparatus are not specifically outlined in the diagrammatic pictures. This advertisement in the journal of the Society of Chemical Industry must have been seen by a large number of people, both in Great Britain and America, as this journal has a wide circulation in both these countries.

I have carried out an experiment with the apparatus illustrated by Figure 1 of the patent in suit, and I used for this purpose "Defendant's Exhibit, Apparatus of Patent in Suit," adding, of course, thereto the necessary baffles. 500 grams of Defendant's ore, crushed in my presence to 80 mesh, were made into a pulp with 3200cc. of water containing .5% of sulphuric acid. The temperature of the mixture was 35 degrees Centigrade (95 degrees Fahrenheit). 0.75cc. of oleic acid were added thereto, and the mixture was agitated for about ten minutes. It was then allowed to settle and showed a froth of about one and a half inches in depth. After re-agitation, the mixer was emptied out into the spitzkasten, which were filled with water having the same temperature as the mixture in the cone mixer. A froth appeared filling about the two first spitzkasten. It was collected on filters dried and weighed. Its weight was 107 grams. The tailings recovered from the spitkasten, looked

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clean. It is unfortunate that the whole of the Gabbett apparatus cannot be completely emptied out. The residue contained therein, which had the appearance something like the original ore, weighed 136 grams. To collect this residue, it was necessary to pour water into the Gabbett and tilt the Gabbett over and let it run into another basin, and to wash with the wash bottle the Gabbett out. Naturally the froth was broken up, and sunk in this operation and mixed with the tailings, and the impression from superficial observation was that the color resembled the color of the ore. If the apparatus were used as it is intended for continuous work, such residue would not result because there would be continuous addition of new pulp and the residue would be treated with the new pulp. There could only be in a day's work one residue left, which would not appreciably influence the result of the recovery. As a matter of fact, it would have no influence, as it would be treated the next day.

An assay of the 107 grams recovered showed the presence of 49.5% of zinc.

Adjourned to Monday, November 4, 1912, at 10:30 in the forenoon, at the same place.

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New York, November 4, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

irect-examination continued:

Answer to 37-Q. continued: The quantity of zinc ntained in the 107 grams of concentrates recovered described in the previous experiment in the appar- us marked "Defendant's Exhibit, Apparatus of Pa- nt in Suit," was 52.9 grams. The 500 grams of ore sed in this experiment contained 18.5 per cent. of nc; that is, 92.5 grams. The recovery, therefore, ould be 57.2%. I have, however, explained that 136 rams remained in the cone mixer, as they could not run into the spitzkasten. The zinc content of these 36 grams was 15.1% of zinc, or 20.5 grams, and ese 20.5 grams have to be deducted from the zinc ntent of the ore submitted originally to the treatment the process of the patent in suit. The zinc con- nt of the 500 grams of ore was 92.5 grams, which, ter the deduction of the 20.5 grams of zinc remain- g in the cone mixer, leaves a zinc content of 72 grams the ore, on which an actual recovery was obtained, d this recovery was 52.9 grams or 73.5%. The tail- gs weighed 245 grams and contained 5.3% of zinc, at is, 13 grams.

I used 500 grams of ore originally. I recovered as

Concentrates	107	grams
Residue in cone mixer	136	"
Tailings	245	"
	488	grams.

I, therefore, lost in this operation 12 grams or 2.4% of ore. The zinc content of the ore was 92.5 grams. I found in the

Concentrates	52.9	grams
Residue in cone mixer	20.5	"
Tailings	13	"
	86.4	grams.

I lost, therefore, 6.1 grams of zinc, equal to 6.6% of zinc. This loss is easily accounted for by a permissible error in the different assays and by the loss of the 12 grams of ore in the operations. The 12 grams of ore represent the zinc content of 2.2 grams of zinc.

I have frequently made experiments with this apparatus and I have never failed to produce a froth on the spitzkasten. The froths varied in size and covered sometimes only one spitzkasten, sometimes two, sometimes nearly two, of the apparatus marked "Defendant's Exhibit, Apparatus of Patent in Suit." I attribute these variations to the imperfect arrangement in the tap of the outlet pipe of this apparatus. This outlet pipe is provided with a globe valve, that is, a valve in

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'hich the water flows first upward, then downward, nd then again upward, when the tap is unscrewed; ıe gangue has time to settle and prevents the flow of ıe mixture contained in the cone mixer. This ocurred in every experiment which I made with this pparatus and the passage of the mixture contained ı the cone mixer had to be started by vigorous suc-on. The valve ought to have been a gate valve, which orms, when the tap is unscrewed, a straight line with ıe two connecting pipes. But even in spite of this un-uitable valve, the recovery was always obtained as a roth.

I gather from the cross-examination of some of the vitnesses, that the defendant contends that a froth s not always formed, but that the recovery is some-imes the result of skin flotation. That is not so; it is lways a froth. I have tested this in every experiment made with the apparatus marked "Defendant's Ex-ibit, Apparatus of Patent in Suit." In every experi-nent I made, I allowed the mixture first to settle in he cone mixer after agitation, and in every instance a eavy froth separated. Mr. Sulman suggests the pos-ibility that the force of surface tension of a large are water surface might cause the expanding of the roth and change it into skin flotation. I have seen he ends of a froth, when a large, free water sur-ace was left, stretch out and present the appearance of skin flotation. But on close examination, air bub-les densely covered with minerals were seen. But,

even if the froth should stretch or expand under abnormal conditions into skin flotation on being exposed to the force of a large bare surface of water, either in the beginning of the daily work or perhaps owing to a breakdown of the machinery, surely that has nothing to do with the real question, namely, that the result of the agitation in complainants' process is the formation of a froth. This froth results always from complainants' process. It is immaterial whether it is collected after its formation either as froth or as skin flotation, or whether it is sunk in the tank and destroyed and collected as finely divided minerals. Any form of collection may be used which prevents its remixing with the tailings. The real invention contained in complainants' patent in suit is the separation of minerals from ore as a froth by agitating a mixture of pulp and oil in such manner that air is beaten in, and that, after allowing the mixture to settle after the agitation a froth carrying the oiled minerals forms on the surface of the water.

I have said before that the apparatus, Figure 1 of the patent in suit, is intended for continuous work, and it is stated, page 2, line 53, that there may be any number of cone mixers in series. The number of cone mixers to be used, it is self-evident, would be such as to make the best use of the spitzkasten, to keep them completely covered with the froth so as to prevent the breaking of the froth, and to keep the circuit in continuous activity. I notice on page 167 of Defendant's

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ecord that Dr. Byrnes describes experiments with te apparatus offered in evidence and marked "Defendat's' Exhibit, Apparatus of Patent in Suit." He does ot mention that he experienced any difficulty in emptyig the cone mixer through the valve with which it is ovided, into the spitzkasten. I can only repeat what have said before, that I had to apply suction in every periment I made. He also succeeded in fully emptyig the cone mixer into the spitzkasten, in which operaon I failed. He says:

> "The cone being maintained in motion, wash-water was added to remove the residue, and the vessel was slightly tilted to empty out the portion contained in the concave bottom."

I cannot conceive how the cone mixer could be tilted whilst the agitator was running and running at 1600 volutions a minute. I know of no way how this can done. Furthermore, the operation of pouring in war from a height on a froth might easily result in the ineral being sunk and removed from the sphere of ncentration. But the chief objection to this experient is, that Dr. Byrnes did not carry out the instrucons of the patent to introduce air into the mixture of ılp and oil by agitation to form the froth. The cone ixer used was without baffles, that is, without the element necessary for the introduction of air into a liquid, d the necessity of the presence of baffles would be vious to any metallurgist, whether he knew of the

apparatus or not. The patent clearly says that the ag tation must introduce air, and Dr. Byrnes might hav readily used one of a number of apparatuses of whic he says later on in his summary that they could hav been used for such purpose according to his expei ments, and one of which had been described for intro ducing air into a liquid by agitation to effect a chemica action, namely, oxidation, in the process of the gol recovery by means of cyanide solutions (Stoveken Pat ent No. 729,805). Dr. Byrnes used the cone mixer without baffles and he succeeded, even with this de- fective apparatus, to produce some froth. He says (page 167):

> "Some froth floated down the shallow trough and over the body of the water contained in the spitzkasten, passing on into the launder and being collected and filtered."

Dr. Byrnes continues on the same page as follows:

> "Considerable mineral, in the form of fine individual oiled particles, also floated down on the surface of the water, as a mere film supported by surface tension."

This shows clearly that there was an insufficiency of air to produce a froth, but that some air was introduced which effected skin flotation, if Dr. Byrnes was right in his observation that what he saw was skin flotation and not an expanded froth including fine air bubbles

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overed densely with minerals such as I have seen to ccur sometimes in this apparatus.

Dr. Byrnes used in this experiment .135% of oil of he amount of ore treated. That is a quantity near nough to the quantity found by the patentees as "suitble and economical," and which statement Dr. Byrnes as recorded in the beginning of paragraph 2 of page 15 of Defendant's Record. I was surprised to find, n the first paragraph contained on page 180 of Deendant's Record, no reference to this statement. Dr. Byrnes had apparently quite forgotten it, although it orms the keystone to the ordinary working of the rocess. He says that the patent

> "in the specific 'example' simply specifies 'a very small proportion of oleic acid (say, from 0.02 per cent. to 0.5 per cent. on the weight of ore),' a very wide range, with no statement or indication as to whether the 0.02 per cent. is preferable or the higher limit, twenty-five times as much, or what conditions are to determine the amount to be used."

As I said, he has forgotten the important statement on page 1, line 96, of the patent in suit:

> "The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

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And the complaint which Dr. Byrnes made is not justified by fact.

Dr. Byrnes states in paragraph 2 on page 168:

> "From my study of the prior art, and from my tests of the processes disclosed therein, as well as of the process in suit, I am entirely unable to find any point of novelty in the process described and claimed in the patent in suit, so far as it is carried out by the use of the apparatus shown in Figure 1."

As Dr. Byrnes has given a summary of the essence, at least as he tries to interpret it, of the prior art, I will criticize that part of the above statement which refers to the prior art when I am considering this summary. But he limits his conclusions in this statement to the use of the apparatus shown in Figure 1. He has not used the apparatus described in the patent in suit and diagrammatically illustrated by Figure 1. He omitted that part of it which is essential to the process of the patent in suit. The patent tells you to agitate for the purpose of beating in air. That he has not done and his conclusions as drawn from the working of Figure 1 of the patent in suit are faulty.

The last paragraph of Dr. Byrnes' answer referred to, pages 173, 174 of Defendant's Record, states that the patent in suit is very vague as to the details of the process and as to the proportions of oil and acid to be employed. He says here again what he has also stated on

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age 180 of Defendant's Record, namely, that the patnt specifies the proportion of oil and acid,

> "say from 0.02 per cent, to 0.5 per cent. on the weight of the ore,"

and continues later on—

> "Later the description states, in the most general terms, that the proportion may be 'under 0.1 per cent. of the ore.'"

He omits deliberately to state the end of the sentence, losing the quoted part from the patent in suit (page 1, ines 100, 101):

> "may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical."

This is a distinct statement and sufficient guidance or any metallurgist to work upon. It is impossible to e more accurate in a process which may be used for a arge number and variety of different ores, and it is impossible to demand of a patentee that, for the purpose of his patent specification, he should try to collect all ores from the different parts of the world and describe a specific treatment for each of them, with specific proportions of all the ingredients for each of them. They give as an example the well-known Broken Hill ore, with which they appear to have been very familiar. They inform the world what they consider the limits of their proportions, and they add that in their experience

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0.1 per cent. of oil of the amount of ore has been found "suitable and economical." Surely one cannot demand more, and even a metallurgist of very low qualifications cannot fail to determine with the greatest ease what quantities will give him the desired results. Dr. Byrnes then states that the amount of sulphuric acid or other acid or salt to be added may be any fraction under one per cent. or up to one per cent. This statement is again not a full statement of what is contained in the patent, because the patent says that the water should contain a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt. I cannot find any reference to a salt, only acid salt. The reason for the addition of acid is stated plainly on page 1, lines 41-44:

> "to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked."

It is well known to any metallurgist, and it must have been well known to Dr. Byrnes that ores frequently contain small quantities of substances which absorb mineral acids and that therefore it was impossible for the patentees to fit all varieties of ore which are in existence with one coat. The object of the patentees is to have an acid reaction; that means, the faintest quantity of acid present during the process of oiling, and as long as a test paper, after having been wetted with the pulp, shows acid reaction, the condition of the patent is ful-

illed. These are such simple tests that, if a student ıfter a few months' study was not capable to carry them ›ut, he was sure to be severely censured. It is the asiest thing to find within five or ten minutes the quan-ity of acid which will answer the purpose of the paten-ees. Dr. Byrnes has a very low appreciation of the ıbilities of metallurgists.

As to the suitability of the different oily substances or the separation of minerals from ore, different types of oil and different oils of these different types have een frequently described prior to the application for he patent in suit, and were well known to people con-ersant with the art. Dr. Byrnes apparently expects, at east that is the only conclusion I can come to from hese remarks on pages 173, 174, of Defendant's Rec-ord, that the patentees ought to have tried every oil in existence with every ore in existence and ascertained or every ore in existence the quantity of sulphuric acid which will leave faint acidity during the operation of he process of the patent in suit. Such a patent would ill a fairly large volume. Of course, the suggestion hat every oil should have been tried by the patentees s absurd. The patentees give a fair warning, page 1, ines 61-69:

> "The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the

> concentration of any particular ore, a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired."

And the patentees describe specifically the use of oleic acid, thereby indicating which of the oily substances they found efficient. The number of oils which may be used is very large, and all that can be demanded of a patentee is to explain how one can determine by a simple test which of a large number of substances suitable for the purpose of a patent is the most suitable and economical. It is, of course, essential that the patentee should state which substance he found in his experiments the best, and the patentees of the patent in suit have done so.

Dr. Byrnes then complains that the agitator or mixing vessel shown is confessedly old with Cattermole and is relatively inefficient. The patent in suit does not claim any novelty for this apparatus. But I deny that this apparatus is inefficient, and I say it is only inefficient as used by Dr. Byrnes with parts of the apparatus omitted. If properly used it is an excellent apparatus for the purpose of the patent, and it was also an excellent apparatus for the Cattermole process. The froth-separating apparatus I agree with Dr. Byrnes is, as shown in Figure 1, a very old device and I need not add that it is not claimed as a novelty in the patent in suit.

As to Dr. Byrnes' conclusions, I disagree with him,

particularly with his statement that the patent in suit describes and claims no new process. In my opinion, the process disclosed in the patent and set out in the claims is a fundamentally new process, which involves a hitherto unknown phenomenon. I shall sum up the prior art later in my deposition.

Adjourned to Wednesday, November 6, 1912, at 10:30 in the forenoon, at the same place.

New York, November 6, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Direct-examination continued:

38-Q. Have you had a reproduction made of the Froment apparatus, as described in the testimony, which was delivered by Alcide Froment to Mr. John Ballot and his associates during the latter part of the year 1903?

By Mr. Scott: The question is objected to as calling for secondary and hearsay evidence, in that it does not appear that the witness ever saw the apparatus in question or that he has any knowledge of its construction, in this connection it being noted that the record of this suit, upon which the witness will presumably base his answer, contains nothing but the most meagre references to the con-

struction, form and dimensions of the apparatus referred to.

A. I inquired, after having read the testimony and the description of Froment, for the apparatus which had been sent by Froment at the end of 1903, but I was informed that this apparatus had been destroyed long ago, as it had proved of no value and quite inefficient. I had, therefore, an apparatus constructed after consultation with the metallurgist of Minerals Separation, Ltd., Mr. A. Howard Higgins, who had used the apparatus. I did not have the whole of the apparatus made for the obvious reason that the screens had nothing to do with the question in issue. I had made the mixer and the vat with the coil. I now produce this apparatus.

By Mr. Williams: The deposition of the present witness is interrupted for the production of Mr. A. Howard Higgins as a witness to more fully identify the details of construction of the reproduced Froment apparatus just produced.

A. HOWARD HIGGINS, the witness produced in behalf of the complainants, having been duly cautioned and sworn, testifies as follows:

1-Q. Are you the same A. Howard Higgins who has heretofore testified in this suit, at the request of defendant's counsel, as a witness for defendant?

A. Howard Higgins.

A. I am.

2-Q. I now show you the apparatus produced by Dr. Adolf Liebmann as a reproduction of the Froment apparatus received by Mr. John Ballot and his associates in the latter part of the year 19~~1~~03, which original Froment apparatus you have testified was seen and used by you. Please state whether or not this apparatus is an accurate reproduction, as to details of construction, of such Froment mixer and such Froment vat with coil.

A. The apparatus is almost an exact copy of the original received, with one exception. The mixer vessel was possibly one to two inches less in diameter and had no covers. The agitating mechanism is, as far as I can remember, an exact copy, as is also the vat with coil containing the rake.

Direct-examination closed.

Cross-examination by Mr. Scott:

3-XQ. Have you any recollection at this date regarding the relative number of teeth upon the different gears in the original Froment apparatus?

A. As far as I remember, they were about two to one.

4-XQ. Have you any recollection upon this point other than a general idea, that is, did you take any

special note of this relation when you had the original machine before you?

A. My idea that I am right in this answer is based upon the turbulence of the liquid when operating the machine, which seems to be about the same as that in the original apparatus.

5-XQ. The two beaters of the original Froment machine have been described by a witness in this suit as "made of stout wire, somewhat like grid-irons." What parts of the apparatus produced by Dr. Liebmann embody this construction of beaters made of stout wire like grid-irons?

A. Possibly the elliptical frames carrying the horizontal arms.

6-XQ. By horizontal arms do you refer to the small pieces of angle iron screwed to the elliptical frames?

A. I do.

7-XQ. In operating the original Froment machine, did you make any observations as to the number of revolutions per minute imparted to the agitators which you can use as a basis of comparison with the speed of revolution of the stirrers in the apparatus produced by Dr. Liebmann?

A. I have no record of any observations on the speed of these beaters, but feel certain that they would be rotated at the highest speed convenient, which I consider to be between 300 and 400 revolutions per minute.

8-XQ. Is it your recollection that the original Froment apparatus did have stirrers consisting of stout wire somewhat like grid-irons?

A. Howard Higgins.

A. The apparatus produced by Dr. Liebmann is the embodiment of the recollections I have of the Froment machine, which I may say are quite clear, the beaters being, as I have said, an exact reproduction.

9-XQ. It is not your recollection, then, that the beaters of the original Froment machine consisted of stout wire somewhat like a grid-iron?

A. No, I should not describe them that way.

10-XQ. At the time you saw the original Froment machine, did you make any comparison between that machine and any drawings of the Froment apparatus whereby you could now state more definitely than from pure memory as to whether the apparatus produced by Dr. Liebmann is like the original Froment apparatus?

A. I made no comparison of the apparatus with the drawing, and it is, therefore, only possible for me to say from memory that the apparatus is the same.

11-XQ. Did you see any drawing of the Froment apparatus at about the time you saw the original Froment machine?

A. No.

12-XQ. And I presume you made no drawing of the machine which you saw or any written notes describing it.

A. I have not found any.

13-XQ. Have you made any search for such notes or drawings?

A. I looked through my notes to see whether I had any information on this subject.

A. Howard Higgins.

14-XQ. Did you look through all of the records to which you had access which might possibly have contained information upon the construction of the original Froment apparatus?

A. I looked through those only in my possession.

15-XQ. You mean in your personal possession?

A. I include as well those in my possession in my capacity as metallurgist to Minerals Separation, Ltd.

16-XQ. Did your search include all of the records of Minerals Separation, Ldt.?

A. No.

17-XQ. Were you instructed by Minerals Separation, Ldt., to make a search regarding the construction of the Froment machine through all of their records bearing upon that point, including such records as were made during and after the tests which were performed prior to the purchase of the Froment patent by Minerals Separation, Ltd., or by parties acting in the interest of the organization subsequently known as Minerals Separation, Ldt.?

A. I have no recollection of any such instructions.

18-XQ. At the time you saw the original Froment machine, did you see any written description of the machine or of the mode of operating it?

A. No.

Cross-examination closed.

A. Howard Higgins.

Re-direct Examination by Mr. Williams:

19-RDQ. Did you prepare for Dr. Adolf Liebmann specimen of Broken Hill ore by desliming it?

A. I did.

20-RDQ. And was or was not such desliming in ccordance with ordinary metallurgical practice?

A. On a laboratory scale, certainly.

21-RDQ. Exactly how did you deslime it?

A. The ore was placed in a bucket, a stream of vater directed into the bucket so that when the same vas full there was a constant overflow. During this eriod the ore was carefully stirred up in the bucket. By these means the slime was washed out. When he overflow water was almost clear, the operation was topped, and the surplus water poured off.

22-RDQ. Was that the condition of this ore as to rushing before you deslimed it?

A. It had been crushed through a 60 mesh screen.

Re-direct Examination closed.

Deposition closed.

A. Howard Higgins.

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Deposition of Dr. Adolf Liebmann resumed:

> The apparatus produced by Dr. Liebmann as a reproduction of the Froment apparatus in the particulars stated is now offered in evidence and the mixer is marked "Complainants' Exhibit, Reproduction of Froment Mixer," and the other piece of apparatus is marked "Complainants' Exhibit, Reproduction of Vat with Coil."
>
> Mr. Scott: The introduction in evidence of the exhibits referred to is objected to upon the ground that the evidence does not show that the exhibits are what they purport to be, namely, reproductions of apparatus sent by Froment to the complainants or their predecessors.

39-Q. Mr. Higgins has testified that he prepared for you a specimen of Broken Hill ore by desliming it. Please state what tests you made with this deslimed ore.

A. I performed yesterday, together with Prof. Chandler, who has been ill and who was only the first time capable to leave his house after his protracted illness, in the presence of counsel for complainants, the following experiments:

1. The ore which had been deslimed by Mr. Higgins was not quite dry. We, therefore, first analyzed what amount of moisture was left in it. We found it contained 15% of water. We took a quantity of ore corresponding to 2½ kilos of dry ore and filled it into the Froment mixer. I should mention that the ore was

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roken Hill ore. We then added 6 liters of water and ?½ grams of engine oil and agitated the mixture at a eed as near as possible of 300 revolutions per mine. I say as near as possible, because as this apparatus ows it is worked by hand and it is impossible to say r certain whether the speed was always the same. might have been at times greater and at times perps slower. 50 grams of calcite had been added. he agitation lasted about fourteen minutes, but after n minutes the agitation was stopped and the mixture amined. There was a thin film of oil on the top, extremely ~~erely~~ thin, and there was some air bubbles in it. The ed ore was at the bottom of the mixer. It was examined also before it was emptied out and the same pearance was observed, namely, a thin film of oil with me air bubbles on the surface of the liquid and the ed ore at the bottom. The mixture was then, whilst ng agitated, emptied out into the vat provided with e coil, but only water ran out and the ore had to be shed out with water. When everything was conned in the vat provided with the coil, the rake conned therein was turned around at a speed of about to twelve revolutions per minute, and 143cc. of died sulphuric acid, containing 35% of sulphuric acid, s poured in through the leaden pipe which ends in e of the perforated coils at the bottom of the vat. t no appreciable amount of minerals were carried the top. I should say, scarcely any appeared. Although the depth of the ore was such in the vat with

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the coil that the rake worked in it, the construction of the rake in my views is wrong and the rake is inefficient for the purpose it is intended for. It cuts grooves into the ore pulp and moves in the same grooves after they have once formed. The experiment proved only two facts: that the oil settles both in the mixer if the agitation is stopped and in the vat with the coil at the bottom, and that the only thing which appeared on the surface of the mixture is a thin film of oil.

I arrived at the conclusion that neither the construction of the agitator contained in the mixer is suitable and efficient, nor the construction of the rake contained in the vat with the coil. I, therefore, made an experiment, as follows:

2. A quantity of the deslimed ore, corresponding to 500 grams of dry ore, was filled into a cone mixer 1200cc. of water, 12½ grams (14cc.) of engine oil, and 10 grams of calcite were added, and the mixture was agitated in the cone mixer for ten minutes at a speed of 300 revolutions per minute. After ten minutes agitation, the apparatus was stopped and the mixture examined. There was, just as in the Froment mixer, a thin film of oil on the surface of the liquid. The oiled ore was at the bottom. The mixture was again agitated and, whilst being agitated, run out into a wide shallow vessel. The oiled ore was, as before, at the bottom of the vessel; a film of oil, but no minerals on the surface of the liquid. The mixture was gently stirred by hand with a spatula and 30cc. of dilute sulphuric acid con-

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taining 35% of sulphuric acid gradually added to it. A layer of oil with concentrates appeared on the surface. It was removed and further 30cc. of the same acid added, the result being that more minerals appeared on the surface having the look of a magma; that is, of a pasty mass of oil and minerals enclosing some carbonic acid bubbles. The concentrates thus obtained looked very good, but the tailings were not quite clean. If the minerals and oil were allowed to remain on the surface, that is, not collected, they fell again to the bottom after a short time. As I stated, I worked at a speed of about 300 revolutions in the cone mixer. This speed is given in the instructions obtained from Froment as proper speed. But as it is a speed for a larger vessel, thought it fair to repeat the experiment with a much greater speed.

3. A quantity of the deslimed ore corresponding to 00 grams of dry ore (Broken Hill ore) was filled into slide machine, 1200cc. of water, 14cc. of engine oil 12.5 grams, equal to 2½% on the ore), and 10 grams f calcite were added thereto and the mixture was agitated in the slide machine at a speed of 1600 revolutions per minute. The agitation was stopped after two minutes. A film of oil was on the surface of the liquid. he oiled ore was at the bottom. The result was identi-l with the result obtained either in the cone mixer or the Froment mixer. The mixture was then slowly gitated at about twelve turns per minute. This was, course, done by hand, that is, by moving the belt

driving the agitator by hand, whilst, at the same time, 30cc. of dilute sulphuric acid (containing 35% of sulphuric acid) were gradually added. The concentrate rose in the form of a magma to the top. It was removed and had the appearance of a very good concentrate.

In these experiments I went out of my way to give the Froment instructions the best chance of success and, as is seen from the description of my experiments, I used apparatus in experiment 3 which was not available at the date when the Froment instructions were received. These experiments confirm that the process revealed by the Froment instructions can be carried on in a laboratory for the concentration of ore, but is of no use for an economical concentration today nor was it at the time when these instructions were received.

The ore which I used in these experiments was, as is stated, Broken Hill ore. It contained 17% of zinc and 6% of lead. The instructions of Froment direct the use of mineral engine oil. I used in these experiments mineral engine oil of the best quality known as Mobiloil, and which is a mineral oil. The instructions as to the quantities of oil to be used are as follows:

> "If the ore contains more than five per cent. of metallic matter such as copper, lead, it will be necessary to add a little more oil. As a general rule, one may assume:

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1% of oil for ore containing up to 5% of metals; 1½% of oil for ore containing up to 10% of metals; 2% of oil for ore containing up to 15% of metals."

As this ore contained 23% of metal, I used 2½% of the oil, which was also in the proportion of 50 lbs. of oil to the short ton of ore.

40-Q. Did you perform any other tests yesterday in the presence of Dr. Chandler and myself, and, if so, what did you do?

A. I performed the tests with Dr. Chandler which I had made before and which are described in my answer to 34-Q as the test tube reproduction of Dr. Byrnes' alleged Froment experiments in the slide machine described in Defendant's Record, pages 165, 166. The results were exactly the same as I have described before. They did not produce the Froment result described in the patent, nor did they produce any separation of the values from the gangue.

41-Q. Please now give consideration to the summary of the prior art given by Dr. Byrnes, commencing at the middle of page 168 and ending at the middle of page 173 of Defendant's Record.

A. Dr. Byrnes makes his summary of the prior art under different headings. He first enumerates the patents in which he finds the disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ore or for graphite. Then he enum-

erates the documents in which he finds a disclosure of the use of acid. Then he enumerates the documents in which the flotation of oiled minerals by attachment thereto of bubbles of air or gas is disclosed. Then he enumerates the agitators, which according to his tests may be used for entangling atmospheric air and beating it through a mixture. Then he states that widely different amounts of the same oiling agent have been used and finally he enumerates the patents in which heating of the oil or of the mixture of pulp and oil has been described. Dr. Byrnes' mode of making this summary of the prior art is very misleading and it is not a summary which can be used as a guidance to ascertain the true state of the art and what is revealed therein. It may be called an index of the contents of the different documents, but it is not a revelation of the process es used therein and of the facts produced thereby. An invention is not anticipated because some of the steps have been used before it was made to produce different results. If that were so, the progress of the world would be arrested and further inventions would be impossible. There are innumerable chemical inventions which use the same chemical substances, which use the same steps in producing a new result. I will give an illustration of what I mean. If you treat, for instance, napthol with sulphuric acid at 70° Centigrade, a new compound, a combination of napthol and sulphuric acid, is obtained. If the same napthol is treated with sul-

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phuric acid at 20° Centigrade, the result again is a combination of the napthol with the sulphuric acid. The latter compound, when submitted to certain chemical reactions, produces one of the most beautiful red colors in existence. The former compound does not yield, until the identical treatment, any color whatever. Another example of the variety of action is shown in cotton. If cotton be acted upon by dilute sulphuric acid containing as little as .025% of sulphuric acid, it is tender. If cotton is treated with dilute sulphuric acid containing about 50% of sulphuric acid, it is rendered white and lustrous, it is what is popularly called mercerized, and stronger than it was originally. The novelty in a patented invention is not destroyed because one or two steps had been known before. The novelty depends on the process as a whole and on the novelty of the result produced, and it does not matter whether any of the steps or all of them had been used before for different purposes, and it does not matter whether some of them had been used in earlier attempts to achieve a similar object and had failed. That rather increases the value of the invention, because the former failures were a warning against renewed attempts.

Dr. Byrnes' first point is that he finds a clear disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ore in several enumerated patents. As the patentees admit this in their specification of the patent in suit and specifically

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refer to two of the patents which Dr. Byrnes enumerates, to wit, Cattermole, No. 777,273, and No. 777,274 (Sec., page 1, lines 16-27), Dr. Byrnes is merely stating what the patentees admit.

Dr. Byrnes' second point is that he finds a clear disclosure of the use of acid, for example, sulphuric acid, including small amounts of acid, in process of oiling the metalliferous constituents of ore, with statements that acid increases the preferential affinity of oil for the metalliferous constituents, in certain enumerated patents. This is undoubtedly true and no point of novelty is made as to this in the specification of the patent in suit, and the same two patents which Dr. Byrnes includes under this point are specifically referred to in the patent in suit as above stated. As I have said, this was the invention of Carrie Everson.

Dr. Byrnes' third point is that the flotation of oiled minerals by the attachment thereto of films or bubbles of air or gas or by the adhesion of the oiled particles to bubbles of air or gas is disclosed in certain prior patents, which he enumerates. That is true of some of them, but it is not true of the Schwartz, Kirby and Froment patents. In these documents it is oil which includes minerals and gas bubbles and this mixture is floated.

Under this point he also says that he can use agitators of prior patents for the purpose of the patent in suit. Now that he has learned of the invention, this may be true. Probably there are a great many

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agitators in existence which can be used for the purpose of the process of the patent in suit, but the important fact is that none of them was used for that purpose. His reference to the Everson patent is altogether wrong. Everson describes no agitator at all, but only agitation sufficient to cause the mixture of mineral, oil and acid, with oil in very considerable quantities, the oil and mineral being removed by a constant overflow well known at the time, and the operation being possible because the oil and mineral are lighter than the sand or gangue. None of the patents mentioned depends for its success on the beating in of air by means of an agitator. In some of the documents mentioned such agitation which would result in the beating in of air would be impossible; in others it would prevent the achievement of the result. I cannot pass over this paragraph without comment on the remarks which Dr. Byrnes makes about the Froment test tube examples (page 170). I utterly disagree with the following statement:

> "In his (Froment's) test-tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oiling agent also thoroughly aerates the mixture, the fine bubbles of air distributed throughout it, and attaching themselves to the oiled particles, acting with the chemically evolved gas to float them.'"

There is not a word mentioned in the Froment

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patent about aeration by atmospher~~e~~ic air and I further say that such aeration is utterly impossible according to the description which Froment gives of his test tube example.

Dr. Brynes' fourth point that widely different amounts of the same oiling agent have been used is true, but it is not true that oils have been used under 1 per cent. or a fraction of 1 per cent. of the weight of ore, as stated by Dr. Byrnes on page 171. It is certainly not true that the phenomenon of the patent in suit, namely, the agitation froth, has either been produced with large or with small quantities of oil. The only document which discloses comparatively small quantities of oil, namely 4 to 6 per cent. on the minerals, is Cattermole, and he does it for the definite purpose of increasing the falling power of the minerals in order to be able to collect them at the bottom of the classifier.

Dr. Byrnes' fifth point is that the use of warm water or a warm mixture is an obvious and necessary expedient where oleic acid is used. That is not only not obvious but quite unnecessary for the purpose of oiling, as ordinary commercial oleic acid is a liquid at normal temperatures. The red oil used by defendant is an impure oleic acid, and, therefore, not as liquid as ordinary commercial oleic acid. According to my opinion, the increase of temperature plays a different part from that which Dr. Byrnes tries to explain at such length on pages 171, 172 and 173. It is a well

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known physical fact that the power of occluding gases, that means, the power of attracting gases, increases with the increase of temperature with metals, and the superior results which are obtained at the higher temperature I attribute to this well known physical fact.

From Dr. Byrnes' summary nobody can gather any information whether any of the alleged anticipations describes the process and the result, either identical or similar to the process or result of the patent in suit. Dr. Byrnes' summary is not a summary, but an index.

Adjourned to Thursday, November 7, 1912, at 10:30 in the forenoon, at the same place.

New York, November 7, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Direct-examination continued:

42-Q. I now call your attention to the answer of Dr. Byrnes to Q-15, appearing at pages 182-185 of Defendant's Record, and also the answer of Dr. Byrnes of XQ-65 appearing at pages 213, 214 of Defendant's Record, the conclusion of the reasoning of these two answers appearing to be that the Cattermole granulation process is an oil-gas flotation process. What have you to say as to this testimony?

A. The answer of Dr. Byrnes first mentioned in

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your question, which is contained on pages 182-185, i again a proof of the difficulty present in the mind of certain people that they cannot put themselves bacl to and ~~from~~ form a correct opinion of the knowledge of a earlier time. They interpret always by the late standard. But even with this explanation, this answe of Dr. Byrnes is very surprising. An unbiased minc reading these two documents, namely, patents Nos 777,274 and 788,247, which have been correctly called the soap patents, would know at once that they are intended for the use of the same quantity of oil as has been revealed in the Cattermole patent, No. 777,273, and that they use, instead of oil, soap, and produce the oil therefrom, as the patentees call it, *in situ,* which means in the mixture, by the addition of acid. No. 777,274 describes the recovery of the concentrates by granulation. No. 788,247 describes the recovery of the oiled particles by skin flotation and refers to any of the well-known methods for producing the effect of skin flotation. The expression,

> "only seek to coat every particle of metalliferous matter as thinly and evenly as possible,"

occurring in an argument filed by the applicants for their patent No. 788,247, surely is quite clear and is only capable of one interpretation, namely, that the object of the patentees was to coat every particle of metalliferous matter as thinly and evenly as possible, as was known at the time, and that was with the quantity

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of oil used by Catternole, and disclosed in patent No. 777,273, the difference being that, in the latter document, the oil was present as such in the mixture whilst in the former the oil was generated from soap. I will quote the paragraph of the argument in which the above quoted sentence appears:

> "A very important line of distinction between Everson's process and the Applicants' is that Everson oils the whole of the *ore and gangue* initially as thoroughly as possible and seeks to wash the gangue out of the mass by acid water or the like. The Applicants on the other hand avoid any oiling of the gangue by wetting the whole first with water and by such preferential wetting and the mode of producing the oleic acid *only the metalliferous matter present is coated.* The Applicants never make a pasty mass of the whole ore, but only seek to coat every particle of metalliferous matter as thinly and evenly as possible and therefore to keep the gangue and the mineral particles from agglomerating together."

The argument was used to differentiate the process from Everson's earlier invention described in patent No. 348,157. Everson mixed the ore with oil first. In order to do this, she had to use considerable quantities of oil. When the mixture of oil and ore was then treated with water and acid, the gangue was cut out and there was a large quantity of oil in excess, in which the oiled mineral particles were embedded. In

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the process used in patent No. 788,247, the oiling of the gangue did not occur, and therefore there was no excess of oil present in which the oiled particles would unite together. The coating with oil can only of course refer to the coating with such quantities as were known at the time, and the lowest quantities used known at the time were the quantities of Cattermole. Everson used for making the paste 18% of oil of the amount of ore to be treated. It is in evidence that the Cattermole process was tried mainly for Broken Hill ore, which contains about 25% of minerals. Cattermole, Sulman and Picard only oiled the values and not the gangue, and they would require only 6% of oil if they were to produce the same effect as Everson did with 18% of oil. As a matter of fact, Cattermole found 4 to 6 per cent. of oil a suitable quantity in proportion to the mineral in the ore, or 1.4 to 2 per cent. of oil in proportion to the ore with which they mainly experimented. I repeat that the statement, coated as thinly as possible, can only refer to the coating of minerals as was known at the time and not to the coating of minerals which was discovered long after, and disclosed in the patent in suit.

There is a wide difference between the coating with oil as disclosed in patents No. 788,247 and No. 777,274, and the coating with oil as disclosed in the patent in suit, and it is quite apparent from the quantities which are described as useful in the two different sets of patents. In the Cattermole patents No. 788,247 and

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No. 777,274, the quantity is clearly alike with the quantity disclosed in Cattermole patent No. 777,273, and that is 4 to 6 per cent. on the minerals, (1.4 to 2 per cent. on the ore), with a warning that the process is not to be used with lean ores. In the patent in suit the quantity found suitable is .1 per cent. Expressed in pounds per short ton, Cattermole requires 28 to 40 lbs. as a useful quantity, and the patent in suit describes 2 lbs. as a useful quantity. Furthermore, it is a necessity for the Cattermole invention that the oiled particles can be granulated and rendered specifically heavy, heavier than the gangue. In other words, they must have a greater falling power than the gangue, so much greater that the gangue can be removed by an upcast, or an upward flow of water, whilst the granules are not removed thereby. The Cattermole granules have an oily look, no luster, no light is reflected therefrom. The oiled particles of the patent in suit appear as a froth on the surface of the liquid. They are brilliant, metallic looking substances, no oil can be discerned on them, and it is impossible to obtain granulation from them. There is no overlapping possible in these two patents. Cattermole warns you against the use of lean ore. If you want to treat lean ore, add granules to it, which have already been formed, or other matter having affinity for oil, or pulverized mineral matter which had been obtained from an ore. It is clear that he has in his mind as a suitable ore for his treatment Broken Hill ore. The patent in suit dis-

closes as a suitable and economical amount .1 per cent. of oil. It is true that the patentees do not limit themselves to this quantity, but that is the quantity which, on careful reading of the specification, would suggest itself to a metallurgist.

As to Dr. Byrnes' answer to XQ-65, I disagree with the same. I say that the Everson process depends on the reduction of the specific gravity of the minerals by oil and the sinking of the minerals is prevented by an upcast. Glogner and Good are oil buoyancy flotations. Patent No. 788,247, a soap patent, results in skin flotation a~~ssisted by ga~~s, and the same is true of No. 793,808 to Sulman and Picard. Patents No. 807,501 and No. 807,503 to Schwartz depend on oil buoyancy flotation assisted by gas, and the same is true of No. 809,959 and No. 876,626 to Kirby. British letters patent No. 12,778 of 1902 to Froment depends on oil flotation assisted by gas produced in a nascent state.

I disagree absolutely with the long argument contained on page 214, in which Dr. Byrnes tries to show that Cattermole is an oil-gas flotation process. Cattermole does not disclose anything but the formation of heavy granules, so heavy that they remain at the bottom of the liquid even after the introduction of an upcurrent of sufficient force to carry the gangue away.

It is again an attempt to alter the character of an earlier invention by the introduction of later processes and later investigations. It is particularly unfortu-

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ıte and uncalled for with the Cattermole patent, which a brilliant invention, clearly written and well deıed both as to process and to result.

43-Q. Will you please now give a summary of the ıtents referred to in the deposition of Dr. Byrnes?

A. The patents referred to by Dr. Byrnes in his eposition may be roughly divided into three classes, amely:

1. Apparatus.
2. Processes for ore treatment by means of water.
3. Processes for ore treatment by means of oil.

APPARATUS.

The patents disclosing the invention of apparatus nd the literature quoted as disclosing an apparatus re:

Wagner, No. 373,113;

Stoveken, No. 729,805;

Extracts from Treatise on Chemistry applied to Manfacture of Soap and Candles.

Wagner discloses a churn by which he alleges he an produce lactic acid by the action of the oxygen of ir on sugar. It has been introduced apparently for he purpose to show that it was known that air could e introduced into a mixture by agitation, and that a hemical action could be produced thereby, and that in his way casein could be coagulated and separated from he butter when the butter globules are ruptured by gitation. Such an apparatus would not stand up nder the severe conditions of agitating a gritty ore pulp.

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Stroveken describes an apparatus for the extraction of precious metals, and more especially gold, from ores of low grades. It is an agitator destined to bring air into the mixing of the ore with a weak cyanide solution, in order to effect a rapid and complete solution of the gold and silver contained in the ore by providing the oxygen necessary for the chemical action. It has no reference whatever to the concentration of ores by means of oil.

The extract from the Treatise on Chemistry applied to the manufacture of Soap and Candles has no reference to ore concentration. It is intended to fill a liquid soap with air bubbles so that its specific gravity is reduced, and that it can float on water.

I submit that there is nothing disclosed in these documents which could shed any light on ore concentration by means of oil, and I further submit that there is nothing contained in these documents disclosing the process of the patent in suit.

2. PROCESSES FOR ORE TREATMENT BY MEANS OF WATER.

The following patents fall under this heading:

Bradford,	No. 345,951;
Hockley,	" 466,753;
Rouse,	" 469,599;
Hebron & Everson,	" 471,174;
Delprat,	" 735,071;
Delprat,	" 768,035;
Potter,	" 776,145.

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Bradford's invention consists in processes for saving materials floating on water and to collect losses occurring on Rittinger tables, Frue vanners, and jigs. An ore, when immersed in water, will produce with part of the minerals skin flotation, and Bradford's invention was to collect these minerals floating as skin flotation. There is no oil used whatever and the economy which is effected is due to the well-known phenomenon of skin flotation, and no slimes can be treated with it.

Hockley discloses an apparatus to save the float mineral, usually called slimes and sometimes flour gold and silver, by surface tension flotation. He assists to produce this flotation by means of an upcurrent, which may be air, water or steam. When the particles arrive at the surface, they will float on exposure to air. It is a simple surface tension phenomenon and no oil is used to produce it.

Rouse discloses a process for the saving of slimes from water used in grinding ores. This water contains sometimes valuable minerals and Rouse saves it by bubbling air into the water. The principle is the same as in Hockley. He uses an upcurrent rapid enough to prevent the descent of the slime water. He does not use oil.

Hebron and Everson disclose an attempt to reduce the specific gravity of minerals by attaching to them substances of much lower specific gravity. It is not quite clear whether the patentees thought that their

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flotation was due to specific gravity. The process, i ~~by~~ my opinion, is a surface tension flotation process. N oil is used.

Delprat in his two specifications describes the carr ing of minerals to the surface of water by means gas bubbles generated in the mixture. The gas bu bles attach themselves to the mineral and lift it to tl surface. No oil is used.

Potter is like Delprat, a flotation of minerals b gas bubbles generated in the mixture, no oil being use

3. PROCESSES FOR ORE TREATMENT B MEANS OF OIL.

Under this heading I shall treat the patents in fou sub-headings, as follows:

(a) Oil and ore mixed, and mixture treated wit acidulated water;

(b) Pulp treated with oil; concentrates separate from surface;

(c) Pulp treated with oil; concentrates separate from bottom of liquid;

(d) Pulp treated with oil; concentrates floated b introduction of gases through pipes or generation o gases in the mixture.

Under the sub-heading (a) I include the followin patents:

Everson,	No. 348,157;
Schwarz,	" 807,501;
Schwarz,	" 807,503.

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Under the sub-heading (b) I include the following patents:

Elmore,	No. 676,679;
Elmore,	" 689,070;
Glogner,	" 736,381;
Good,	" 745,960;
Kendall,	" 771,075.

Under the sub-heading (c) I include the following patents:

Cattermole,	No. 777,273;
Cattermole, Sulman & Picard,	" 777,274.

Under the sub-heading (d) I include the following patents:

Froment,	No. 12,7~~8~~8 of 1902; 7
Sulman & Picard,	" 793,808;
Cattermole, Sulman & Picard,	" 788,247;
Kirby,	" 809,959;
Kirby,	" 838,626.

(a) Oil and ore mixed and mixture treated with acidulated water.

Everson discloses two proceses in her patent. According to the first, she produces a stiff mass by mixing the ore with a compound prepared by mixing a small quantity of sulphuric acid with cotton seed oil. The dough-like mass is then kneaded in water, by which operation the gangue is removed. It is not a

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practical process and has never been used. The quantity of oil which she advises is in proportion of about 6 grams of oil to 112 grams of ore (over 5 per cent.), which is 100 lbs. of oil to the ton of ore, and which is altogether prohibitive.

Everson's second process depends on the reduction of the specific gravity of the ore by such quantities of oil and to such an extent that the mixture of mineral, and oil is lighter than the gangue, and on the separation of such a mixture of mineral and oil by an up-current of water. She mixes the pulp with ~~the~~ a quantity of oil amounting to 18% of the ore, or 3~~7~~60 lbs. of oil to the ton of ore. The process is out of question on account of its high cost, even if the process would work. No froth is produced and no satisfactory separation of values from the gangue can be obtained by this process according to my experiments made in strict accordance with this Everson patent.

Of the Schwarz patents, the first one states as the object of the invention the conversion of valuable oxides or carbonates into sulphides and adds the description of an oil separation process for the recovery of sulphides thus obtained by means of oil. The separation process of sulphide minerals from the gangue is more fully described in the second patent. Schwartz makes first a paste of his ore and oil (the oil is a mixture of two different oils in certain quantities, which at ordinary temperatures is solid), and then blows air or gas through pipes into this paste. To be able to do this, he must at least use a quantity of 50% of oil,

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or 1,000 lbs. to the ton of ore; otherwise, he could not blow the air in and keep the mixture of ore and oil in the vessel. Such a paste is pretty thick and he could only use slow agitation with it. He then mixes water with it and continues the blowing in through pipes of air or gas to assist in the distribution of the water throughout the paste and to effect the thorough washing out of the tailings. Schwartz' recovery is due to oil buoyancy flotation assisted by the enclosure of air bubbles in the oil. Some of his oil is recovered by a centrifugal drum or filter press. The process is far too expensive to be of practical value.

(b) Pulp treated with oil; concentrates separated from surface.

The two Elmore patents depend on oil buoyancy flotation pure and simple, and they differ from each other that in the one no acid is present, whilst in the other one an acid is present. Only heavy oils are used. The extraction of the ore with oil is repeated so often until the tailings are clean. The quantity of oil used in these processes is roughly three tons of oil to one ton of ore treated, assuming an ore such as Broken Hill ore is treated. A large quantity of this oil is recovered by centrifugal separation. It appears from the testimony that this process was practically used to some extent, but abandoned long ago.

Adjourned to Friday, November, 8, 1912, at 10:30 in the forenoon, at the same place.

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New York, November 8, 1912.

Met pursuant to adjournment.
Present—Counsel as before.

Direct-examination continued.

Answer to 43-Q continued. The Glogner patent describes a process for purifying graphite from its natural mineral impurities. The heavier impurities have to be removed first before the material is submitted to treatment. It is then mixed with three or four times the quantity of water and petroleum is added in a quantity amounting to one-half the quantity of pure graphite contained in the ore. The mixture is contained in a suspended vessel, which is moved like a pendulum by hand at a speed of 30 shocks per minute, which movement induces the sunken mass to turn over and to come into contact with the petroleum. After settling, the petroleum, which contains part of the graphite, is removed and the operation is repeated once, twice or more, each time after the addition of fresh petroleum, until the graphite has all been separated from the mixture. The process results in the removal of the graphite by buoyancy oil flotation.

Good's invention refers to an apparatus for separating graphite or other materials from associated impurities. He does not say what the other materials are and describes the use of his apparatus only for graphite He makes the separation in three steps: (a) by sur-

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face tension flotation on water without the use of oil; (b) by oil buoyancy flotation; (c) by preferential grinding of the graphite in a mixture of coarse graphite and sand and separation of the so ground graphite from the sand by a screen. There are no details whatever given of the oil flotation. It is clear from the construction of the tank that it can only be used for oil buoyancy flotation, and, furthermore, that the agitator in the tank can only be used for very slow agitation. Nothing is contained in this document which has any bearing on the patent in suit and, even with the knowledge of today, the apparatus described could not be used to produce the effect of the patent in suit. It is a patent only for an apparatus.

Kendall describes another process for the separation of graphite from ghaphite ores or graphite waste by means of kerosene or paraffin oil, which by reason of its levity carries the graphite to the surface. It is an oil buoyancy flotation process.

(c) Pulp treated with oil; concentrates separated from bottom of liquid.

Cattermole, No. 777,273, Granulation and Cattermole, Sulman and Picard, No. 777,274, Soap and Granulation, mark a distinct step in advance. They leave the old path of trying to effect the separation of the values from the gangue by reason of a reduced specific gravity of the mixture of oil and mineral. They choose the opposite way. They increased the size of the fine particles by agglomerating a number of them

together, the oil with which they were coated forming the cement or agglomerant. And in this way they obtained granules of such a size that the law which governs specific gravity and the true falling power in a liquid was established. The values settled on the bottom of a classifier and the gangue, much lighter than the values, was removed by the force of an upcurrent. The well known cone mixer was used for the agglomeration of the oiled particles by agitation, followed by a rolling form of agitation if necessary, the latter to be performed in cylinders or the like. The patentee (Cattermole) warns against the use of lean ores, and the same warning must apply also to Cattermole, Sulman and Picard process, as the only difference between these two patents is that in the latter the oil is generated in the pulp. The quantity of oil recommended is from 4 to 6 per cent. of the amount of mineral present in the ore (1.4 to 2 per cent. on Broken Hill ore), but the amount to be used depends on the sort of granules which are desired as well as on the ore which is to be treated. I have found for defendant's ore that a suitable proportion for this Cattermole process, using oleic acid, was from 6 to 7 per cent. on the mineral, which amounts to from 1.8 to 2.1 per cent. on the ore, and have obtained good granules with these proportions, which are in evidence. The step forward marked by this invention was that for the first time the concentrates sank to the bottom of the vessel and that the gangue was floated off. The quantity of oil

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required, if the quantity recommended by Cattermole is used, is from 28 to 40 lbs. per ton of ore for Broken Hill ore. The quantity which I found suitable for defendant's ore is from 36 to 42 lbs. per ton of ore. I refer to the short ton, unless I state otherwise.

(d) Pulp treated with oil; concentrates floated by introduction of gases through pipes or generation of gases in the mixture.

Froment describes some principle embodying the following phenomena:

1. Natural sulphides moistened by oil have a tendency to unite in spherules and to float on the surface.

2. This tendency is retarded by the specific weight and opposed by the gangue in which the moistened sulphides are embedded.

3. The bubbles of a gas generated in this mass become covered with an envelope of sulphides and rise to the surface as a kind of metallic magma.

4. The formation of these spherules is particularly active if the gas used is in a nascent state.

There is no process described in this patent—only a test tube experiment, from which, however, two important factors can be obtained, namely, the quantity of gas which he wants to generate in a nascent state, and the minimum quantity of oil which he intends to use. He advises the use of 10 per cent. of calcite of the quantity of ore used, which will provide him with 5 per cent. of carbonic acid, and the use of a thin layer of oil which must be at least, according to my actual

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tests, 12½% of the amount of ore used. The result is obtained instantaneously. Froment was manager of an Elmore concentration plant, and it is clear from the introduction that his invention is a modification of the Elmore process. The result is obtained by oil buoyancy flotation assisted by gas bubbles enclosed therein. Froment describes his float as a magma. Ure's Dictionary of Arts, Manufactures and Mines, gives the following definition of this word:

> "MAGMA is the generic name of any crude mixture of mineral or organic matters, in a thin, pastfy state."

This definition is substantially repeated in Murray's and Webster's International Dictionaries, referring to Ure.

The quantity of oil used in the test tube experiment corresponds as a minimum to 250 lbs. to the ton of ore.

Cattermole, Sulman and Picard, No. 788,247, Soap and Flotation patent, depends on the Cattermole process for oiling the minerals and generally refers to known processes for flotation of the oiled minerals. The quantities of oil used are the same as in the Cattermole patent as a minimum. The phenomenon is skin flotation.

Sulman and Picard, No. 793,808, which has been referred to as the Bubbles patent. This is another skin-flotation process, the skin flotation being produced by a number of apparatus. The quantity of oil must be

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such that it will moisten the mineral particles; but should be less than is required for buoyancy flotation by the oil alone.

The two Kirby patents disclose an apparatus and a process for separating the minerals from the gangue by an oil buoyancy flotation assisted by air blown in through pipes at the bottom of the apparatus. This process is an improvement on Elmore, thin oils being used, which oils can be recovered from the concentrates completely by filtration and by distillation of the concentrates. The quantities of oil specified as giving excellent results are 500 to 1500 lbs. of oil per ton of ore.

In none of these alleged anticipations is the phenomenon or the process of the patent in suit disclosed. In none of these alleged anticipations is there any suggestion which would lead anybody towards the process or the phenomenon of the patent in suit. In none of these alleged anticipations is there any suggestion that by beating in air a froth could be produced consisting of air bubbles densely covered with minerals and carrying practically the whole mineral contents of the ore. In none of these alleged anticipations is there any suggestion that a quantity of oil could be used so small that it disappeared and could only be detected on the concentrates, by chemical methods.

I repeat that the patent in suit discloses an absolutely novel and unexpected phenomenon, and an absolutely novel discovery which no one could have foreseen.

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44-Q. Please now include in your summary the patents and publications which were not referred to by Dr. Byrnes.

A. The patents and publications which have been referred to in this evidence, but not by Dr. Byrnes, are as follows:

1. APPARATUS.

The Wolf patent, No. 787,814, discloses an agitator which has been described in the testimony as the Johnson agitator. This agitator is shown at the upper left-hand corner of the drawing. It works in substantially the same way as a cone mixer. Instead of a revolving cone, we have a stationary hollow cylinder supported by radical arms, which act as baffles. A revolving stirrer is located below this hollow cylinder.

2. PROCESSES FOR ORE TREATMENT BY MEANS OF WATER.

The Hebron patent, No. 474,829, is an improvement on the Hebron and Everson patent, No. 471,174. No oil is used. The ore is prepared by heating or vacuum to drive out the air, and to enlarge the holes or pores alleged to be present in the minerals, and a buoy stock is pressed together with the ore and is supposed to attach itself to the mineral. The mineral containing the buoy stock is separated from the gangue by flotation, according to the statement of the patent. This is the last patent in the Everson series and marks the final

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and complete abandonment of the use of oil to effect separation.

3. PROCESSES FOR ORE TREATMENT BY MEANS OF OIL.

The Haynes British patent, No. 488 of 1860, contains the first disclosure of the use of oil for ore concentration. The ore is mixed with oil to form a stiff paste, which is then kneaded with water to wash out the gangue. It is not a practical process.

The Fryer Hill publication of 1889 is clearly a further development of the Everson patent. It adds to Everson the use of heat. The specific agitator which is described as having arasta-like fans probably ought to be arrastre-like fans and is derived from the Spanish word "arrastre," which means to drag. The process so far as it can be determined from this publication is open to all the objections of the Everson process as described in the Everson patent.

The Criley-Everson publication of 1890 is a modification of the Everson process as described in the Everson patent, black thick oil being used instead of petroleum, and water near boiling being used. The experiment appears to have been made in a laboratory. There is a clear disclosure of the use of acid in small quantities as in the Everson patent. No practical process of ore separation is disclosed in this scant description.

The Robson patent No. 575,669, which appears to

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have been partly assigned to Crowder, is for a process which has been referred to in this evidence as the Robson and Crowder process and in this process the ore is moistened with water and then a stream of oil is used to wash out the mineral. On the face of it, it is clear that this process is far too wasteful and expensive to be of any use.

The Cattermole patent No. 7~~5~~63,260 is known as the Emulsion patent and discloses the use of an oil emulsion in the granulation process of patent No. 777,273. The solution is alkaline instead of acid. This is a division of the application on which patent No. 777,273, was granted, and is clearly a variation of the Cattermole process, giving the same proportions of oil as are given in the Cattermole patent No. 777,273.

The other Cattermole patent mentioned by me, No. 763,259, is for the classification or separation of concentrates or granules obtained by the Cattermole process, that is, the separation of the different sulphides from each other. This is effected by retreatment of the granules in an apparatus substantially the same as is disclosed in the other two Cattermole patents with the use of a breaking down solution. This process starts with oiled granules, and is not a process for the separation or concentration of the values contained in an ore.

I can only repeat here what I said at the end of my preceding answer. These patents and publications do not disclose or suggest the invention disclosed in the

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patent in suit. They give further examples of the efforts to solve the problem of ore concentration by oil and of the failure to do so in a practical and economical manner.

45-Q. I call your attention to the testimony of Dr. Byrnes in answer to Q-24, appearing on pages 193-196 of Defendant's Record. What have you to say as to this testimony?

A. I have carefully read the testimony given by Mr. Edward H. Nutter, which he gave with regard to the sample of froth which he collected from defendant's plant whilst it was in operation. I quote the passage contained on page 23 of Complainants' Record:

> "The concentrates froth from *f* and *g*, the frothing boxes of the smaller unit, were flowing into the launder D, and the sample of froth which I took was from the lip of the frothing box *f* as it flowed into the launder D."

Mr. Nutter also testified that this smaller unit was a retreatment unit, and in this he was right, as defendant's witnesses admit. I cannot understand the assertion of Dr. Byrnes that Mr. Nutter pretended to have taken a handful of froth from an alleged sixth frothing box, which did not exist. It is perfectly clear to me that Mr. Nutter testified that he took his sample from the first frothing box of the second unit, which he properly described as the retreatment unit.

As to Dr. Byrnes' remarks that the conclusions which Prof. Chandler drew from his very exact experiments are based on pure speculation, I must frankly confess that I cannot follow the bent of his mind which led him to say this. Dr. Chandler made an analysis by a recognized method, which cannot be improved upon, and drew his conclusions from the results which he obtained. He confirmed the correctness of his conclusions by a series of well conceived experiments which could not be improved upon, and I accept his results as facts, as everyone who knows the great reputation of Prof. Chandler, both here and abroad, will do.

46-Q. Have you read the depositions of Edward H. Nutter, Jesse C. Gibson and James M. Hyde, and the descriptions therein of the apparatus referred to by defendant's witnesses as defendant's experimental plant, from which apparatus Mr. Nutter testified that he took a sample of froth while the apparatus was in operation, and do you understand the construction and operation of said apparatus?

A. Yes.

47-Q. Could this apparatus be used for any of the processes of the patents and publications referred to by you, except the agitation froth process disclosed in the patent in suit, so as to produce a floating froth in the spitzkasten of the type described by Mr. Nutter in his deposition?

A. No.

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48-Q. Assuming that powdered ore, water acidified with sulphuric acid, and oleic acid are fed into the defendant's apparatus referred to and that a floating froth of the type described by Mr. Nutter appeared on the spitzkasten, what have you to say as to the process being carried out under such conditions in defendant's apparatus?

A. I say that a froth thus produced must have been produced by the process of the patent in suit.

Adjourned to Saturday, November 9, 1912, at 10:30 in the forenoon, at the same place.

New York, November 9, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Direct-examination continued.

49-Q. As I understand it, you have read all of the deposition of Dr. Byrnes in behalf of defendant and are therefore familiar with that part of this deposition wherein defendant's second plant is described?

A. Yes.

50-Q. I now repeat Qs 47 and 48 as applicable to defendant's second plant described by Dr. Byrnes.

A. My answers are the same as to those questions.

51-Q. What have you to say as to the suggestion that the retreatment of concentrates and of the residues obtained from the retreatment of concentrates, consti-

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tute, either separately or collectively, a departure from or an improvement on the agitation-froth process as set forth in the patent in suit?

A. The retreatment of the concentrates and of the residues obtained from the retreatment of the concentrates does neither constitute a departure from nor is an improvement of the agitation froth process as set forth in the patent in suit. It is a mere repetition of the process carried on with material containing different quantities of mineral and gangue.

52-Q. I particularly call your attention to Qs.48-50 and the answers thereto in the deposition of the defendant, James M. Hyde, pages 71 and 72 of Defendant's Record. What have you to say as to this testimony?

A. Qs. 48-50 speak of an odor of sulphuretted hydrogen. I have noted this odor to a very slight extent in my tests of defendant's ore. This odor is not due to the decomposition of the valuable sulphides, but to some other sulphide, probably an iron sulphide which is present in the ore and quite valueless. There is not a trace of the valuable sulphides attacked by the dilute acid present in the pulp mixture. Some suggestion has been made in the evidence that sulphuretted hydogren or hydrogen sulphide might be used like carbonic acid in *statu nascendi,* that is, in the nascent state, as a suitable gas for carrying oiled minerals to the surface. That is not so. Sulphuretted hydrogen is comparatively soluble in water, but that might be overcome. The

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reason why sulphuretted hydrogen cannot be used for this purpose is that it is dangerous to human life. It is one of the most dangerous poisons in existence and I know of several cases in which the leakage, and that a very small one, from a closed vessel caused the loss of human life. To use this gas for the concentration of ores would, if it were done, soon put an end to the concentration process. The very trifling quantities that can be produced in defendant's plants may be unpleasant to the smell, but it is impossible that they contribute in any way to the process of ore concentration. There can only be the very faintest traces of this gas, otherwise it would have a bad effect on the workmen, and from this ore and under these conditions only the very faintest traces of this gas can be produced. Such very faint traces are appreciable to the smell. That is all.

53-Q. I now particularly call your attention to Q-8 and the answer thereto in the deposition of Dr. Byrnes, pages 178, 179 of Defendant's Record. What have you to say as to this testimony?

A. The answer of Dr. Byrnes is very much involved and difficult to understand for the ordinary mind. It has been a well established fact, since the time of Everson's discovery, that the presence of acid in a mixture of pulp, and oil cuts the gangue out, and it has been well known that the presence of acid in a mixture of pulp and oil prevents the oiling of the gangue, and that is the purpose for which acid is present. If an ore

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contains calcite, which is an easily decomposible carbonate, then the amount of acid must be larger than if there was no calcite present, in order to enable the sulphuric acid to fulfill its mission, namely, to prevent the gangue from being oiled. In defendant's ore rhodochrosite, or manganese carbonate, is present to a slight extent, and I have proved experimentally that it is at lower temperatures not readily attacked by dilute sulphuric acid. But if the whole quantity of sulphuric acid which defendant uses would act and produce carbonic acid, there is so much water present during the transit of the mixture of ore and water to the pulp thickener that it would merely pass into solution or into the air. It could not remain in contact with the enormous excess of water without being dissolved, and it would certainly be dissolved during the agitation process later on. This is also true as to sulphuretted hydrogen, if any traces of it should be formed, and, as I have said, nothing but the merest traces of it could appear in defendant's plants.

I am convinced, from my analyses of the gaseous content of the agitation froth, that air is the agent which forms the froth, and that the presence or absence of small quantities of other gases has no effect whatever in the production of the froth, while the consumption of sulphuric acid, which would produce these gases, is a serious detriment to the ecoonmy of the process.

54-Q. I now particularly call your attention to the

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last paragraph of the answer of Dr. Brynes to Q-11, pages 180, 171, of Defendant's Record. What have you to say as to this statement?

A. I say that this statement has no significance whatsoever. I always understood that a patent was addressed to persons conversant with the particular art with which it deals. Metallurgists know that ores are not individuals, but mixtures. Metallurgists know that an ore may contain small quantities of an acid-absorbing substance. It would be impossible for any patentee to give definite amounts of acid in a patented process dealing with a large variety of ores. He can only state for what purpose the acid is present and it is for the metallurgist to obey the instructions of the patentee and to see that there is acid present whilst he performs the process of the patent, and to see that the acid is not consumed by secondary reactions. If the secondary reactions cannot be avoided, more acid must be used, so that there may be free acid to perform the function which the patentees wish it to perform, if it is to be used.

55-Q. It is suggested in the deposition of the defendant that the word "powdered," as used in the patent in suit, means "dry" ore. What have you to say as to this suggestion?

A. Amongst technical men if a substance is to be powdered, that is, finely crushed, it is usually done with water, if water has no influence on the substance; that is, neither destroys it, nor dissolves it. It is much

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easier to crush with water than without water. Powdering means reducing to a fine state of division, and it does not matter whether it is done dry or wet.

56-Q. The defendant has put in evidence a patent granted to him on April 2, 1912, No. 1,022,085. What have you to say as to this patent?

A. I say that this patent contains a description of the process disclosed in the patent in suit.

The patentee calls first attention to the fact that cerain metallic and non-metallic elements differ from each other in their behavior to oils and fats, that the metallic substances are coated thereby, and that they can be separated from the gangue by markedly different surface tension phenomena.

The patentee then states that many ores containing a number of mineral components show, when crushed, that the resulting pulverized material consists of particles which are so fine and of such a colloidal nature that they settle very slowly and interfere with obtaining a high-grade concentrate by the use of a flotation process. The patentee says he has discovered that this settling is greatly promoted by the introduction of a small amount of sulphuric acid, with or without some salts, to a pulp whilst in transit to the flotation device, and he enumerates the advantages which he obtains by this treatment, namely, the partial or complete coagulation of the slimes, which makes the thickening of a pulp possible in the pulp thickener, greater facility in separating the concentrates from the gangue, cleaning

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of the surface of the particles of the floatable minerals and assisting, by the generation of minute bubbles of gas in the pulp and on the surface of the floatable mineral particles, in the desired separation of the minerals from the gangue. The next sentence is a little bit difficult to understand and the conclusion more so, but the assertion is made that by the addition of the acid to the pulp before it reaches the flotation plant a smaller amount of acid may be used.

> "as little as one quarter of a pound of crude acid per ton of ore treated" (page 1, lines 77-79).

A further discovery is announced that the concentrates produced can be retreated with the same process, without in certain cases the use of additional acid or coating agent. The oils suitable for the process are the oils which have been used in former oil ore-separation processes.

The plant shown is substantially the same as in the Hoover patent, No. 953,746, which appears on its face to have been issued to Minerals Separation, Ltd., one of the complainants, except that in the drawing only one agitating box is shown for each spitzkasten, whereas in the Hoover drawing three agitation boxes are shown for one spitzkasten, but the Hyde specification says that

> "each of the agitator tanks may, if necessary, consist of a plurality of connected compartments, each provided with an agitator."

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This suggested modification makes the plants the same, except that the deflector K of the Hoover drawings is omitted, and except also that the Hoover apparatus is repeated so that there are three units in the rougher or first treatment apparatus, and two units in the cleaner or retreatment apparatus.

In the agitator the mixture of pulp and oil is agitated and flows from there through an opening at the bottom into the spitzkasten, in which the froth rises to the top whilst the tailings collect at the bottom and are removed from there by a pump into the next agitator, where they are re-agitated and the treatment is repeated. The froth which rises to the surface of the spitzkasten flows into a launder and from there through a pipe into the first agitator of the cleaner or retreatment apparatus. The froths which form on the second and third spitzkasten of the rougher system, flow also into the first agitator of the cleaner system, and the operation is repeated in this system exactly as in the rougher system, with this distinction that there are only two agitators and two spitzkasten. The froth is collected from there and is ready for the smelter, and the tailings, which are called middlings, are pumped from the bottom of the last spitzkasten into the first agitator of the rougher system to pass again through the treatment of concentration.

The two alleged novelties are treatment of the pulp with sulphuric acid before it reaches the flotation plant and retreatment of the concentrates.

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As to the first, namely, the settling of slimes and preparation of the pulp by treatment with sulphuric acid, this is described in Richards' Ore Dressing, a standard work in metallurgy, and appears in Volume II, Section 869, pages 1147, 1148, which on the title page is stated to have been published in New York and London in 1905. I quote the following which is given as a test of the use of sulphuric acid for the purpose of settling an ore pulp:

> "Time of settling, ½ hour; sulphuric acid 0.15 per cent. 100; sulphuric acid 0.29 per cent. 96; sulphuric acid, 0.57 per cent. 99."

I have taken these figures from the table and the numbers 100, 96 and 99, respectively, represent the percentages of total slimes settled out during this period of one-half hour with the respective porportions of sulphuric acid stated. This shows that a very small percentage of sulphuric acid gives the best results.

A metallurgist, wishing to thicken his pulp and to save his slime, would add his acid before the pulp goes into the pulp thickener or dewaterer, and that is just what the patentee Hyde has done.

An advantage claimed by the patentee Hyde for the addition of sulphuric acid before the pulp is mixed with oil is

> "the cleaning of the surface of the particles of the flotable minerals"

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before they are submitted to the oiling treatment. I call attention to the British patent No. 17,328 of 1906, granted to Minerals Separation, Ltd., as a communication from George A. Chapman. This patent specifically refers to the British patent for the agitation-froth process, No. 7803 of 1905, corresponding to the patent in suit, and describes as an improvement upon it that better results are obtained if the pulp is first agitated with acidified water and the treatment with oil postponed to the second or later agitator.

Another advantage claimed by the patentee Hyde for the addition of sulphuric acid before the pulp is mixed with oil, is that minute bubbles of gas are generated in the pulp and on the surface of the floatable mineral particles, which bubbles assist in the desired separation of the mineral components of the ore. This statement is not in accordance with fact. The quantity of gas which can be generated by the quantity of sulphuric acid stated as being used is so small that it could be ever so often dissolved by the quantity of water present, and what is not dissolved will escape into the air.

The other alleged novelty of the Hyde patent is the retreatment of the concentrates by the same process by which the original ore was treated. There is no novelty in this. It is a characteristic of the agitation-froth process that the quantity of oil is so minute and so firmly attached to the metallic particles that they can be agitated over and over again without removal of the invisible oil films on the particles. Re-agitation of a dirty

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concentrate is simply re-agitation of an ore pulp which is richer than the original ore pulp, and return of the residue or middlings from the agitation of such a dirty concentrate is simply good metallurgical practice if anything can be gained by it, and it is the ordinary practice in any well conducted factory.

57-Q. Please now briefly describe patent No. 979,857 issued to Minerals Separation, Ltd., as the assignee of Theodore J. Hoover, on December 27, 1910.

A. This patent discloses an apparatus for carrying on the process of patent in suit, and shows a combination of agitators and spitzkasten with six agitators and three spitzkasten arranged in very nearly the same relation as in Defendant's Experimental Machine, the only difference in arrangement being that each spitzkasten has two agitators in series instead of the successive spitzkasten having three, two and one agitator, respectively.

Direct-examination closed.

Adjourned to Monday, November 11, 1912, at 10:30 in the forenoon, at the same place.

New York, November 11, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Mr. Williams: An offer is now made to repeat in the presence of defendant and his counsel any

of the tests or experiments testified to by the witness, this offer to be availed of at any time during the cross-examination.

It is stipulated that Volume II of Richards' Ore Dressing, referred to by the witness, was published and circulated during the year 1905. Sec. 869, appearing on pages 1147 and 1148, of Richards' Ore Dressing, the book referred to, is offered in evidence to be replaced by a copy thereof, marked "Complainants' Exhibit, Extract from Richards' Ore Dressing," and the entire book is handed to defendant's counsel for use in cross-examination.

Cross-examination by Mr. Scott:

58XQ. Referring to that paragraph of your answer to Q-34 beginning with the words "I took 10 grams of defendant's ore, which had been crushed in my presence to 80 mesh, mixed it with 30cc. of water." I ask you to state to what you attribute the failure of the operation described in that paragraph to produce a froth containing the sulphide ore particles.

A. That experiment was not performed with the intention of producing a froth. That experiment was performed with a view of finding out whether the quantities which Dr. Byrnes had used were such quantities as would come under the Froment patent, and whether the Froment result namely, a magma, could be obtained. I was convinced that it could not be obtained, and the result proved that I was correct.

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59-XQ. In the paragraph above referred to, you state that "practically all the ore was at the bottom, some slimes and oil, which could be observed by its glistening, at the top." Does not this condition of affairs indicate that the agitation had been insufficient, either in degree or duration, to distribute the oil, thereby causing it to adhere to the sulphide particles?

A. No. It only shows that there was an insufficiency of oil to carry out the Froment test tube experiment. I have stated that I found experimentally that 12½ per cent. would be the least amount which could be used according to the Froment description and instructions in the patent.

60-XQ. If, in the experiment described in the paragraph above referred to, you had increased the degree or the duration, or both, of the agitation, would the amount of oil used have coated the sulphide particles and have caused the formation of a floating mass containing the sulphides or a considerable part of them?

A. If, instead of using the instructions of Froment, I had used the knowledge of today, and the directions of the patent in suit, I might have got a float, as you say. I have never performed this experiment in a test tube and cannot say with absolute certainty what the result would have been.

61-XQ. In the experiment described in the paragraph above referred to, did you agitate the mixture contained in the test tube as violently as you conveniently could by manipulating the test tube by hand; for in-

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stance, did you shake it as violently as you would a medicine bottle which is labelled "Shake well before using?"

A. Much more than that, although there is no call in the Froment patent for such agitation. The Froment patent and the test tube example contained therein call for such agitation as would be necessary to bring the sulphuric acid in contact with the limestone, and, as there is a large excess of limestone, the very simplest shaking will effect that result, and if it is not carefully done, the reaction will be as violent as the patentee has described. The contents of the test tube are ejected from it by the sudden evolution of carbonic acid.

627 Q. In the experiment described in the paragraph above referred to, you operated with defendant's ore. In operating upon that ore in the manner described in that experiment, have you found the evolution of carbon dioxide to be so rapid, violent and great in amount as to make it necessary to restrain the degree of agitation which you impart to the mixture in the test tube?

A. I pressed the lower end of the thumb on the test tube and shook first for two seconds what one may call violently. Then I made an observation and after that shook again for six to eight seconds. The amount of carbonic acid which could have been evolved was so small that it would have been dissolved in the water which was present. It requires only 17cc. of water for solution. From experimental experience I have grave doubts whether any carbonic acid was evolved at all.

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63-XQ. Then, in performing the experiment described in the paragraph above referred to of your answer to Q-34, it was not the fear of an excessive generation of carbon dioxide that caused you to limit the period of agitation to two seconds and to an additional six or eight seconds. Am I right in this?

A. No. I did not limit the time of agitation. According to my reading of the Froment patent, I extended the time. If the Froment quantities are taken, as described, two seconds is ample time to see the phenomenon which he has described. It is an instantaneous reaction.

64-XQ. Are the proportions of the different substances used in the test tube experiment, which you describe in the paragraph above referred to in your answer to Q-34, such proportions as you would be induced to use by a reading of the patent in suit?

A. These proportions are within the patent in suit.

65-XQ. These proportions being within the patent in suit, do you adhere to your statement made in your answer to XQ-60 that you cannot say with absolute certainty what the result would have been had you followed the directions of the patent in suit?

A. Yes, for the following reasons. The patentees say, the quantities of oil found suitable and economical are .1 per cent. The quantity used was .3 per cent. The patentees say, one cannot give proportions for every ore, but a simple experiment will teach all that is required. I had not made that simple experiment and the answer which I gave is correct.

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66-XQ. Is the reaction between sulphuric acid of the strength resulting from mixing a few drops of sulphuric acid with 30 grams of water and a carbonate always instantaneous, regardless of the character of the carbonate, that is, regardless of what base enters into the carbonate, regardless of the condition of the carbonate as to its state of crystalilzation, or whether it is a precipitated carbonate? I may also add to this inquiry whether the quickness of the reaction is not also related to the temperature?

A. No. The difference, for instance, of crystalline structure and amorphous structure makes a difference in the evolution of the gas. For instance, if you use precipitated carbonate of lime or marble, there is a difference in evolution. The difference between different carbonates is also marked. For instance, limestone in finely powdered condition is much more readily attacked than crystallized manganese carbonate. Heat nearly always favors chemical action. Then there is another important factor, whether the acid is used in more concentrated or more dilute form. There are numbers of instances known in chemistry in which acid of a certain dilution fails to produce a result, which in more concentrated form is easily produced. Froment was fully aware of this difference in the behavior of carbonates.

67-XQ. And any metallurgist or chemist, even of comparatively low qualifications, would be aware of the different behavior of different carbonates under the dif-

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ferent conditions to which you have referred in your preceding answer, would he not?

A. Quite so, and that is the reason why Froment advises the addition of limestone to the ore.

68-XQ. I understand, therefore, that your statement in answer to XQ-63, embodied in the words "it is an instantaneous reaction," is not a statement of universal application, but merey refers to the fact that, when a proper carbonate in a proper condition is selected, and the proper acid in its proper condition of dilution is selected, and when the temperature is adjusted at the proper point, a practically instantaneous reaction may result. Is my understanding of your answer correct?

A. My answer to XQ-63 is quite clear:

> "If the Froment quantities are taken, as described, two seconds is ample time to see the phenomenon which he has described."

It clearly refers to limestone. Other carbonates may result in instantaneous action if the proper conditions can be found.

69-XQ. Do you find anything in the British Froment patent to indicate to the metallurgist that an instantaneous reaction would take place between sulphuric acid of the dilution used by you in the experiment described in the paragraph of your answer to Q-34 above referred to, and the kind of carbonate contained in the ore used by you in that experiment?

A. I find from the British Froment patent that the

quantity of acid used in this experiment would be absolutely useless for the production of the Froment result, namely, the production of metallic spherules to form a magma clearly separated from the rest of the liquid.

70-XQ. The amount of acid necessary to react with a given quantity of carbonate involves only elementary knowledge, does it not, and is something that would be obvious to any chemist or metallurgist, even one of comparatively slight qualifications?

A. Yes, the amount of acid is determined by the amount of carbonate which is to be decomposed. That is knowledge which every beginner ought to have.

71-XQ. And if, in following the directions of the Froment British patent, the operator were to use some carbonate that did not readily react with the acid employed, it would be obvious to him, would it not, that he should adjust the temperature and other conditions to the point favorable to such reaction?

A. No, that is not at all obvious. If it were only the intention to produce carbonic acid, then such adjustment would be permissible. But if it is only an incident in a different and novel process, which depends or may depend on other conditions and reactions, then such a proceeding would not be obvious.

72-XQ. If the operator, in carrying out the process described in the Froment British patent according to the directions therein contained, found that there was no reaction or a very slight reaction between the acid and

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carbonate, these being present in the proper proportions, would it not be obvious to him, if he desired to promote the evolution of carbonic acid, to apply heat to the mixture upon the presumption that the temperature was too low?

A. That is not the way I look upon such a proceeding. In my view, the obvious thing to do would be to add the limestone as prescribed by the patentee. That seems to me the only fair way of carrying out the instructions contained in an example of a patent, unless the patentee directs you to do differently.

73-XQ. In dealing with this subject of temperature, do you intend to convey the idea that the metallurgist, n carrying out the process of the Froment patent, is not, according to your idea, expected to utilize his elementary knowledge of the art, including his knowledge of the elementary principle that the reaction between many substances, including that between a mineral acid and a carbonate, is in many instances dependent upon he temperature of the reagents?

A. The metallurgist is, in my view, not entitled to use heat in a process such as the Froment process. There are physical phenomena involved in this process o which heat might be detrimental. As I said, if it were a process simply for the production of carbonic cid, that would be a different matter, but it is not so. The very fact that Froment describes the addition of mestone is sufficient for metallurgists to see how he wants the process carried out. There is no earthly rea-

son why a metallurgist should deviate from the prescription.

74-XQ. Do you consider the evolution of carbon dioxide so unimportant a detail of the process of the Froment British patent that the metallurgist would not be expected to utilize his elementary knowledge to an extent sufficient to adjust the temperature and other conditions to that point where carbon dioxide would be evolved, as directed by the patentee?

A. The generation of carbon dioxide is the important factor which enables Froment to carry out his invention, but the real process begins only with the utilization of the carbonic acid produced, and the question of temperature might have a very serious effect on the result. I repeat that, in my view, no metallurgist should deviate from the process as described. I consider the evolution of carbonic acid as directed by Froment as an important factor in the Froment process.

75-XQ. The evolution of carbon dioxide being an important factor in your view of the Froment process, would it not be the obvious thing for the metallurgist to adjust the temperature and other conditions to the point where this important factor would be present?

A. No, it would not be an obvious thing to do. The obvious thing clearly is to carry out the process as described by an inventor.

76-XQ. It is in evidence that the pulp in some localities has a temperature only two or three degrees above freezing. Is it your idea that a competent metallurgist

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would apply the Froment process to a mixture such as described in this patent, utilizing water only a degree or two above freezing, and, under other circumstances, in a locality where the available water was of a high temperature in precisely the same way and without utilizing his knowledge that temperature has an important effect upon the reaction necessary to produce carbon dioxide?

A. The temperatures which the patentee intends to use are normal temperatures, such as they occur in places where operations of this kind are usually carried out.

77-XQ. What temperature is this normal temperature which you refer to?

A. Such temperature may vary within certain limits, but I believe that the usual temperatures are somewhere about 15° to 16° Centigrade (59° to 61° Fahrenheit); it may be a few degrees up or down.

78-XQ. Then is it your understanding of the Froment British patent that the metallurgist, attempting to carry out that process, would be justified in considering the process a failure unless he secured the necessary evolution of carbon dioxide at the particular temperatures which you have named, namely 59° to 61° Fahrenheit?

A. My reading of the Froment specification is, that the process should be carried out at normal temperatures. I cannot quite understand the question. If you mean to ask me whether the failure of the process

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might be due to a variation of the temperature which had been used, then I cannot answer the question, as I have no experimental experience about it. If you mean to ask me whether such failure might be injurious to the validity of the patent, that would be a question for the courts. I am sorry to be a little dull today.

79-XQ. Suppose a metallurgist attempted to carry out the process of the Froment British patent, the mixture being at the temperatures of 59 to 61 degrees Fahrenheit; suppose that under these circumstances there was no perceptible evoultion of carbon dioxide, notwithstanding the use of the proper amount of acid and carbonates; is it your belief as an expert that the metallurgist of ordinary intelligence would be led to the belief that the process was a failure and inoperative, and that this metallurgist of ordinary qualifications could not be expected to adjust the temperature to a point where the knowledge of his profession would tell him that an evolution of carbon dioxide would take place?

A. I cannot make this assumption. We have to deal with facts, with chemical facts which cannot fail and which always must give the result described by the patentee.

80-XQ. It is well known, is it not, that these chemical facts to which you refer do not give any result unless the conditions be so adjusted as to bring them about?

A. No. It is well known that, in following the Fro-

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ment instructions in the patent, you cannot help arriving at the result described. These facts are elementary knowledge and were known to Froment. There is no necessity for altering the conditions.

81-XQ. Do you find anything in the Froment patent to the effect that this process is to be carried out at a temperature of 50 to 61 degrees Fahrenheit?

A. Yes, most decidedly so. The very absence of instructions means that the process is to be carried out at ordinary temperatures, and the very addition of limestone, which so readily decomposes at ordinary temperature, is further proof of it. If heat were applied in this case, the result would be what he warns against.

82-XQ. If the metallurgist in carrying out the process of the Froment British patent, happened to be in a locality where the available water was of a temperature only three or four degrees above freezing, and the available carbonate was one not easily attacked by a mineral acid at that low temperature, is it your opinion as an expert in this art that the metallurgist would be departing from Froment's instructions if he were to heat the water to a point where his elementary knowledge informed him that the carbon dioxide, which you say is an important factor of the Froment process, would be evolved?

A. As to the last part of the question, I believe I said that carbonic acid is, in so far as it helps to carry out the real process of Froment, an important factor, but this process, as I have stated before, is not a pro-

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cess for the production of carbonic acid. The production of the carbonic acid is one step of several to carry out the invention. As to the other part of the question, I repeat that Froment must have had a reason for advising specifically the use of calcium carbonate (limestone), and I repeat that a metallurgist ought not to deviate from these instructions.

83-XQ. Is it your opinion that a metallurgist, reading the Froment British patent, would derive therefrom the idea that the process was applicable only when limestone was used, as distinguished from some other carbonate or some other mode of generating carbonic acid gas?

A. I gather from the description of the Froment patent, that the patentee intends the use of limestone, and he describes the use of limestone only wherever any definite instructions are given.

84-XQ. Would you, as an expert in this art, understand the Froment patent as indicating that the use of limestone as distinguished from any other carbonate is essential to the carrying out of his process?

A. It has always been my habit, in the reading of patents, to follow the instructions of the patentee, because he is the most competent person to say what his invention consists of. I will say, however, that if any chemist or metallurgist should find a carbonate which would work like limestone under the proper conditions, that is, at the temperature of the process of the patent, at the rate of evolution of gas which can be ob-

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tained from limestone, such a carbonate might be used; but no metallurgist would be entitled to change these conditions. Limestone is, however, so cheap and it is to be found so frequently that there is no necessity for such additional research work.

85-XQ. From your answer I understand that, if the carbonate selected by you did not generate carbon dioxide at a temperature of approximately 59 to 61 degrees Fahrenheit, at the same rate that carbon dioxide is generated from calcium carbonate at that temperature, you would consider yourself outside of the instructions of the Froment patent in using such other carbonate. Is this correct?

A. I have stated that the directions of the patentee are to use the normal temperature and that he must have had reasons for giving them. It is a well known fact, especially with regard to ore concentration by means of oil, that the temperature is of importance, and it was especially known to Froment, who was manager at Traversella Mine, where the Elmore process was worked. In the Elmore process, heat is fatal to the result. The question whether anyone is outside the patent if he deviates from its instructions, is for the Court. As a conscientious person, to work the Froment patent I should follow the instructions of the patent.

86-XQ. I asked you the preceding question and ask you this one for the purpose of ascertaining what a metallurgist would learn from the Froment British pat-

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ent, taken by itself, and without interpretation based upon documents other than the patent itself. I ask you for no opinion upon the legal effect of the patent, but a statement as to the information it conveys to a technical man independent of any experience which you say Mr. Froment may have had, but which was not set forth in the British patent. I ask you, therefore, whether, upon reading the Froment British patent and attempting to carry out the process there set forth, you would consider that you had exhausted the resources of an ordinary metallurgist by applying Froment's directions, as set forth in his test tube experiment, without adjusting the temperature to the point at which carbon dioxide would be evolved, and whether you would consider that you were in your trial of the Froment process, confined to the use of limestone.

A. I say deliberately that any change of temperature would, in my view, be unjustified. I see no reason whatever for deviating from the use of limestone, and I should certainly only work with limestone. I am aware that according to the requirements of the English patent law, the best example how to carry out an invention has to be given, and as this is the only example contained in the patent, I should follow its instructions implicitly.

87-XQ. I take it from your answer that you believe the information to be derived from the Froment patent by a metallurgist is confined to the use of limestone as a source of generating carbon dioxide, and that this pat-

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ent would not teach a metallurgist that other sources of carbon dioxide might be used or that other gases than carbon dioxides might be used. Am I correct in this?

A. I have stated in my direct evidence that this patent is rather a complicated document. It consists of a theoretical speculation and contains as a description of the process a test tube example. From the theoretical speculation, one may infer an absolutely different process, but there is no such process described anywhere, and the only help which a metallurgist gets from it is the test tube example. I will avoid another question and say, that in that part of the patent which I have called theoretical speculation, it is stated that:

> "If a gas of any kind is liberated in this mass, the bubbles of the gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma,"

that might imply the use of other gases, but I know of no other gas which could be liberated in this mass except carbonic acid and sulphuretted hydrogen, and the latter is quite out of the question. I repeat, that, with the exception of the test tube example, we find only theoretical speculation in this document.

88-XQ. My question was directed to ascertain, in the first place, whether you believe the information to be derived from the Froment patent by a metallurgist is

confined to the use of limestone as to source of carbon dioxide in case carbon dioxide is to be used. Will you kindly answer that question?

A. I do.

89-XQ. Referring to the experiments performed by Dr. Byrnes, numbered 3, 4 and 5, and described upon pages 158 and 159 of Defendant's printed record, you have stated, in your answer to Q-34, as follows:

> "I disagree with the result described, which I could not obtain."

Will you describe what operation you performed which resulted in failure to secure the results described by Dr. Byrnes, namely, the production of a froth?

A. Dr. Byrnes' experiments 3, 4 and 5 are represented as experiments of the Froment patent. I disagree with this description. They are not experiments of the Froment patent. In experiment 3, he mixes the Black Rock ore with water. In experiment 4, he adds sulphuric acid to the mixture of ore and water and heats the mixture; that is, he removes the agent which is essential to the Froment process, namely, carbonic acid in the nascent state. Then he waits until the Potter and Delprat result which occurred, namely, the appearance of mineral on the surface of the liquid, has disappeared and the mineral has again returned to the bottom, then he adds one drop of olive oil to the mixture and agitates. He then states that he obtained the magma or froth as described in the Froment patent. That is utterly im-

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possible, for the following reasons: Froment describes ordinary temperature, he describes the formation of a magma by the use of carbonic acid in the nascent state, he describes a layer of oil to be used, and Dr. Byrnes has not followed one of the instructions. I repeat that he could not have produced the Froment magma and that he did not produce it, and, finally, I say that aeration, as Dr. Byrnes describes it, is absolutely foreign to the Froment patent.

When I performed such an experiment, I did not obtain the Froment magma, but the agitation froth of the patent in suit, and the result was not due to carbonic acid, but to a prolonged, vigorous agitation.

90-XQ. Did this agitation froth which you secured contain bubbles of gas covered with an envelope of sulphides?

A. This agitation froth contained bubbles of gas covered with an envelope of sulphides, and it differed in this respect from the magma obtained according to the Froment test tube example. It was perfectly stable, the minerals were brilliant and had a metallic lustre. When it once appeared on the surface, it stayed, and when sunk by force, it could be re-obtained by vigorous agitation. The Froment magma is more like an oily layer containing bubbles of carbonic acid, which are enclosed in oil, in which the minerals are embedded. The magma is not lasting. In the agitation froth, no oil can be discovered. If it is put on blotting paper, it dries, but it retains its shape. If the Froment magma is put

on blotting paper, the oil soaks into the blotting paper and leaves a large spot, and the bubbles collapse. In the agitation froth, the film enclosing the air is water, which is protected and strengthened by a dense layer of the minerals. In the magma there is a layer of oil, which contains carbonic acid bubbles, and the film enclosing them is oil covered with minerals. The difference between the two is that the agitation froth is lasting, whilst the bubbles contained in the magma are not.

91-XQ. On what observation or experiments, if any, do you base your statement that, in the practice of the Froment process, as you interpret that process, the carbonic acid bubbles are enclosed by oil, while in what you term the agitation-froth process the films of the bubbles are composed of water?

A. I base it on my personal observations.

92-XQ. In the operations which you have so observed, how much oil and what kind of oil did you use?

A. I remember having used oleic acid and cotton seed oil, but I am almost sure that I have used a number of other oils. In the Froment process I have used the thinnest layer which could form in a proper test tube, namely 12½ per cent. of oil to the amount of ore used.

93-XQ. How by observation are you enabled to determine whether the film of a bubble which is covered with an envelope of sulphides is formed of water or of oil?

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A. That is comparatively quite easy with Froment, and Froment himself, in what he calls his principles, teaches you how to do it. If you mix your ore, limestone and oil and water together, the oiled minerals fall to the bottom. If you then add sulphuric acid, you can observe how the gas slips into the oil and how, in this way, the bodies are formed which are justly characterized by Froment, as spherules, little spheres. In the agitation-froth process, oil seems to be absolutely absent and it can only be discovered by chemical analysis. The films, therefore, must be water films.

94-XQ. Will you state at what point in the operation described in that paragraph of the Froment patent immediately below the paragraph numbered "4" the oiled minerals fall to the bottom of the test tube, in your answer taking into consideration Froment's statement that

> "the whole of the copperpyrite will instantly rise to the top of the liquid."

A. The test tube example is clearly described as resulting from the principles laid down in the four paragraphs preceding it. It begins,

> "Thus, for example."

I have carried out both the suggestions which are laid down in the four principles, and the process of the test tube example. The result is identical. There is no operation described in the test tube example saying that the oiled minerals fall to the bottom. The reaction

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proceeds so quickly and is so instantaneous that such a phase cannot be observed.

95-XQ. The matters set forth in the paragraphs of the Froment patent numbered 1, 2, 3 and 4 are introduced by the patentee's statement that the following phenomena studied by him have served as the basis of the process which forms the subject of his invention. Would you not, from this statement, understand that the four numbered paragraphs are merely statements descriptive of certain phenomena as distinguished from a description of a method of procedure, and would you not understand that the paragraphs following the four numbered paragraphs are a statement of practical procedure?

A. I should understand from the statement of the four principles which you have mentioned, and the beginning of the example "Thus, for example," that the patentee wishes you to understand that these are the actual facts underlying the test tube example.

96-XQ. Do you find in the Froment British patent any description of a method of carrying out his process, that is, a description of any series of practical operations other than that contained in the paargraph following the four numbered paragraphs?

A. To be quite frank, I do not find any practical process in the Froment document. There are the four principles which would suggest working in a number of steps. Then there is again a suggestion at the end of example 2, from which one can infer that he might

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mean the process to be in a sequence of steps. And then there is the claim, which again claims only a sequence of steps. Yet, there is no description of any process containing or being based on a sequence of steps. The only process I find is a test tube example, and that is not a practical process.

97-XQ. In any of your work, have you succeeded in accomplishing the result described by Froment as taking place in the test tube experiment of the British patent, namely, the flotation of the whole of the metalliferous mineral, copperpyrite in the instance cited by Froment?

A. That I cannot tell. I never succeeded in removing the magma in such manner that the whole was removed without some of it falling back. I never made an assay of the tailing, as it would not have given me any information. I often wondered how Froment arrived at the result.

98-XQ. In your experiments following Froment's description of his test tube operation set forth in the British patent, were you able to form some idea by observation as to whether you succeeded in separating a substantial part of the metalliferous minerals by flotation?

A. I have no doubt that a substantial part of the minerals was obtained on the surface, but I should not like to say or guess how much it was. The magma was not lasting and part began to fall, one might say, at the moment of its birth.

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99-XQ. What do you consider a layer of oil found on the top of water in a test tube—sufficient oil to cover the entire meniscus and to contact with the walls of the test tube, or an amount covering the main body of water in the test tube?

A. In my view, there cannot be two definitions of a layer. A layer of oil is an amount of oil which will cover the surface of the water. Otherwise, it would be called a blob or a globule. There are not two definitions possible.

100-XQ. Do you find that Froment, in his British patent, anywhere states that the layer of oil must cover the entire surface of the water in the test tube?

A. There was no description necessary; the language is quite intelligible. Apparently it did not matter to Froment whether more oil should be used, because he does not call it the thinnest layer, but a thin layer. I used nearly always the minimum quantity, namely, the thinnest layer of oil.

101-XQ. In your operations conducted along the lines of Froment's test tube operation, using 12½ per cent. of oil of the ore, did you obtain the result described in the third numbered paragraph of the Froment patent, namely, bubbles of gas covered with an envelope of sulphides?

A. Always, with the exception of once or twice when the contents of the test tube were blown out. There was always a layer of oil with the Froment spherules embedded in it. Froment calls the bubbles of gas covered with an envelope of sulphides, metallic spherules.

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102-XQ. Is it or is it not a fact that different quantities of different oils are necessary to spread over the surface of water in the test tube to form such a layer as you have defined, namely, one extending to the walls of the test tube?

A. I was struck with the idea which you expressed in your question, and I always believe that actual experiments are the best answer. I tested the quantity of different oils required to form the minimum layer, and there is scarcely any difference between oleic acid and ordinary thin lubricating oil or a heavier lubricating oil, the latter requiring slightly more oil.

Adjourned to Tuesday, November 12, 1912, at 10:30 in the forenoon at the same place.

New York, November 12, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Cross-examination continued:

Answer to 102-XQ continued: I have looked up my notes and I find that with a very thin mineral oil, 8 per cent. are required to form the thinnest layer.

103-XQ. In reply to XQ-58, you stated that the experiment described by you in the paragraph of your answer to Q-34 there referred to was not performed with the intention of producing a froth. What difference

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in procedure would you have followed in performing that experiment if it had been your intention to produce a froth?

A. It is correct that this experiment was not performed with the intention of producing a froth. If I should have wanted to produce a froth, by which I assume you mean an agitation-froth, I should have taken larger quantities of ore, the proper quantities of oil and I would have shaken in a stoppered-up bottle. It is scarcely possible to produce an agitation-froth in a test tube, as a test tube almost always breaks. Then my usual practice was to give the bottle at least a hundred shakes and if no froth had appeared then, I would have continued shaking for fifty times more, and would have made another observation. That is the way I usually carry out experiments which were intended to result in an agitation-froth.

104-XQ. In performing the experiment above referred to, this being the experiment described in the paragraph in your answer to Q-34 beginning with the words "I took 10 grams of defendant's ore which had been crushed," etc., did you place a stopper in the test tube?

A. I have described fully how I did it. I put the lower end of my thumb on the opening of the test tube and closed it up.

105-XQ. Then there was no stopper in the test tube other than the closure formed by your hand?

A. That was the only proper stopper to use, accord-

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ing to the Froment description. Froment says that sometimes the contests are ejected from the test tube. That can only mean such closing up or warning not to have a stopper on and do it in the way I described, and I may add it is the ordinary way, that these experiments are always carried out in a laboratory. No other stopper than my thumb was used.

106-XQ. To state the matter simply, I understand that you did not use a stopper in the test tube because Froment did not mention a stopper and because you feared, in view of Froment's warning, as you term it, that it might have been dangerous to use a stopper. Is this correct?

A. I used my thumb because that is the usual way one does such tests, and it is the only convenient way to gradually reduce certain gas pressure without detriment to the experimenter. I did not expect Froment to describe a stopper. I only knew from the warning that we might expect a certain gas pressure.

107-XQ. In performing the experiment referred to, did you give the test tube as many as a hundred shakes?

A. No.

108-XQ. Is the quantity of ore mentioned and the quantity of oil mentioned as used by you in the experiment referred to, and the relation between these quantities, not adapted to the production of a froth?

A. The quantity of oil in proportion to the ore is about .3 per cent. as used in this test tube experiment, and that falls within the agitation-froth quantities.

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109-XQ. In your answer to Q-34, you refer to the second example described by Dr. Byrnes in the last paragraph of page 165 of Defendant's Record, and state that you reduced the quantities used by Dr. Byrnes to a basis of 10 grams of ore, tried the operation in a test tube, with the result that practically all the ore was at the bottom of the liquid and some oil containing some slimes on the top, the agitation employed by you being described as during two periods, one of two seconds and one of five seconds. In performing this operation, did you put a stopper in the test tube?

A. No.

110-XQ. Did you give the test tube as many as one hundred shakes?

A. No.

111-XQ. Was the violence of the agitation given to the test tube during the seven seconds referred to by you as great as that employed by you when it is your intention to produce a froth, as set forth by you in answer to XQ-103?

A. I should say it was about the same, but it is difficult to form a correct opinion. My experiments concerning the production of agitation-froth were never carried out with less than 50 grams of ore, and this could never have been done in a test tube.

112-XQ. In any of your investigations of this subject did you agitate in a test tube the substances mentioned by you in your test tube repetition of Dr. Byrnes' experiment described in the paragraph beginning near

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the bottom of page 165 of Defendant's Record for a period longer than seven seconds?

A. In none of my experiments referring to the Froment patent, or to questions arising out of the Froment patent, did I shake for a longer period than I mentioned, and in each case, where I followed out the Froment directions, I obtained the result within two seconds.

113-XQ. By "the result," I presume you refer to having all the ore at the bottom of the liquid and some oil containing slimes on the top, this being the result you have described as being obtained in the operation under discussion.

By Mr. Williams: The question is objected to as stating an assumption not warranted by the testimony of the witness.

A. The assumption of counsel that I have considered these experiments as Froment experiments is not correct, and I regret that my description of them and the reasons which induced me to make such experiments have been such as to mislead counsel. To avoid a further misunderstanding, I will now speak out in such language that such a misunderstanding cannot occur again. I consider the experiments of Dr. Byrnes, of which these test tube tests are the translation into the quantities of the test tube example, as utterly absurd and not at all representing anything which Froment described or which could arise out of the Froment de-

scription. It has always been my habit in such cases to treat the opinions of experts on the opposite side with courtesy, and I have always refrained from sharp criticism. I am sorry that this habit of mine, which I cannot alter at my present age any more, should have produced such a misleading impression in counsel. I repeat that the experiments introduced by Dr. Byrnes have nothing to do with the Froment patent. The result which I obtained when operating according to the Froment instructions was not what is stated in the question, but a magma clearly separated from the rest of the liquid.

114-XQ. I call your attention to the fact that, my question numbered 112-XQ, which started the present line of inquiry, made no reference whatever to the Froment process. That question was an inquiry as to whether you had in your repetition of Dr. Byrnes' experiment in question in any case agitated for a longer period than seven seconds. I further call your attention to the fact that you have not answered this question, but have discussed at length what you interpret as Froment operations. I now repeat my question numbered 112 and ask that you kindly answer it?

A. I did not understand your question. As you now explain it I say that I have never made any test tube experiments with the substances and in the proportions mentioned by me in my test tube repetition of Dr. Byrnes' experiments otherwise than as described in my testimony regarding these experiments. I have no notes

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that I varied the time referring to the specific example mentioned by you, and my memory is that they were exactly repeated.

115-XQ. Now referring again to your repetition in a test tube of Dr. Byrnes' second example described in the paragraph beginning near the bottom of page 165 of Defendant's printed record, does your experience enable you to state that, had you continued the agitation for a longer period than seven seconds, or had increased the violence of the agitation, or both, a froth might not have been formed?

A. No. My experience would not have led me to believe that a froth could have been obtained.

116-XQ. Then you are unable to shed any light upon what might happen under these circumstances with a more prolonged or more violent agitation other than your inference formed without actually performing the operation. Is that correct?

A. I cannot state a fact. My opinion before I read this experiment of Dr. Byrnes was that I should find the oily mineral at the bottom.

117-XQ. In your answer to my question numbered 103, you have stated how you would proceed if it were your intention to produce what you term "an agitation-froth." Did you ever perform any operation following the lines laid down by you in your answer to that question, except that you used an amount of either cotton seed oil, olive oil, oleic acid, or other suitable oil, equal to more than one per cent. by weight of the ore operat-

ed on, and particularly did you ever, in such an operation, use an amount of a suitable oil equal to 3.6 per cent. by weight of the ore, this latter proportion of oil being that used by Dr. Byrnes in the experiments described by him beginning with the paragraph at the bottom of page 165 of Defendant's Printed Record and extending through the first two paragraphs on page 166?

A. I have made no such test tube experiments, but I see that your question is not limited to test tube experiments. I have made a number of experiments in which I used more than one per cent. of oil in proportion to the quantity of ore used. They refer to the alleged anticipations which have been produced by the defendant. I find one note in which I say "50 grams of ore, 150cc. of water, ½ gram of sulphuric acid, 1½ grams of oleic acid, all at bottom." This experiment was made on 22nd of July, long before I had read the evidence of Dr. Byrnes.

I have another experiment here in which I used ~~the~~ 400 grams of ore, 1600 grams of water, 4 grams of sulphuric acid and 12 grams of oleic acid. This experiment was carried out in a cone mixer, and the agitation lasted two and a half minutes. The temperature was 44° Centigrade. The remarks are:

"No froth; granules below sand."

This experiment was made on the 23rd of July, long before I had any knowledge of Dr. Byrnes' evidence.

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On the same day I made an experiment with the same quantities, except the quantity of oleic acid. That was 20 grams. The temperature was 40° Centigrade. The remarks are:

> "No froth; granules heavy, much heavier than sand; granules formed bigger during agitation."

This latter part must mean during continued agitation.

Then I have an experiment on the same day. The quantities the same as before, with the exception of the quantity of oleic acid. That was increased to 40 grams and the remarks underneath are:

> "Granules getting bigger and heavier; thin layer of oil on surface."

Where I used 50 grams of ore and 1½ grams of oleic acid, the proportion was 3 per cent. of oil as compared with the ore.

Where I used 400 grams of ore and 12 grams of oleic acid, the proportion was 3 per cent. of oleic acid.

Where I used 400 grams of ore and 20 grams of oleic acid, the proportion was 5 per cent. of oleic acid.

Where I used 400 grams of ore and 40 grams of oleic acid, the proportion was 10 per cent. of oleic acid.

These examples could be continued, but I should like to specifically mention the experiments made with special reference to the Cattermole patent. The quantities of oil used therein are within the limits of your question. The experiments described were made by me only for the purpose of study.

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118-XQ. In your study of this subject, have you familiarized yourself with United States Patent No. 575,669 of G. Robson, granted January 19, 1897?

A. I am familiar with the principle therein.

119-XQ. What is the substance referred to in this patent as colza-oil?

A. I cannot tell you at present what it is, and I am only consoled for my ignorance that I cannot even find a record under this name in one of the best chemical compendiums which I have at hand. I will let you know after I have looked up in an encyclopedia. It is not a scientific name, and probably the commercial name. I see now from the Standard Dictionary that "colza" is rapeseed, and the same "colza-oil" probably means rape oil.

120-XQ. Can you state anything as to the characteristics or composition of this rape oil?

A. According to my recollection, which, however, I trust only with diffidence, it contains the glycerine esther of oleic acid mixed with other substances. Neither the animal nor the vegetable oils are usually definite substances.

121-XQ. Is this rape oil what would ordinarily ~~be~~ be called a fatty oil, as indicated by the patentee Robson?

A. Yes, if my recollection is right.

122-XQ. Can you name some of the substances that would be suggested by the expression "a fatty oil such as colza-oil," this expression occurring in the Robson patent No. 575,669?

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A. Perhaps it will be better for your purpose if I should look up the constitution of the oil first to make sure to give the right interpretation of the sentence in the patent. I will say, if I am right, that it would mean a fatty oil like olive oil and others belonging to this class.

123-XQ. Would cotton seed oil come in this category according to your present recollection?

A. Yes.

124-XQ. In your answer to my question XQ-71, you refer to the production of carbonic acid in the Froment process as "only an incident." From your reading of the Froment British patent, do you arrive at the conclusion that the use of carbon dioxide is of such an incidental character that the ordinary conditions necessary for its production, such as heat in the case of a relatively stable carbonate, should not be created for fear of disturbing some other necessary condition?

A. I have stated that the production of carbonic acid is important, but it is only an incident, because it is a step assisting to achieve the real invention, and the real invention has to be carried out at normal temperatures. No carbonate which requires heat for the generation of gas should be used in this process.

125-XQ. What is this real invention, to which you refer in your last answer?

A. The real invention of the Froment patent is the concentration of minerals contained in an ore, caused by the process of the Froment patent.

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126-XQ. In any of the operations which you performed following the lines laid down by you in your answer to XQ-103, did you obtain any flotation of the metalliferous mineral when using more than one per cent. by weight of oil, that is, one per cent. of the weight of the ore?

A. In all experiments along the line which I described in answer to XQ-103, the bulk of the minerals was always at the bottom. There may have been at times a small part on the surface as skin flotation, and there may have been at times a thin layer of oil on the surface. I am excluding from this answer experiments made with such quantities of oil which resulted partially in oil buoyancy flotation and partly in the collection of the minerals at the bottom of the vessel. But, I should say broadly that the results which I have fully described are the true expression of my experimental experience.

127-XQ. Is your answer to the preceding question limited to those operations in which you used an amount of oil equal to more than one per cent. by weight of the ore? Or does the answer apply to operations including all the quantities of oil which you have used in practicing according to the procedure set forth in your answer to XQ-103?

A. My answer applies to such experiments which started at the lower limit with the Cattermole proportions of oil, namely, about 1.4 per cent. of oil upon the ore.

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128-XQ. Did you ever perform any operations along the lines laid down in your answer to XQ-103, using oil in amounts between 1 per cent. and 1.4 per cent. on the ore by weight?

A. I have no recollection of such experiments. My attention was naturally concentrated on the documents which were referred to by defendant as alleged anticipations.

129-XQ. Will you name all of the different kinds of oils or other selective agents which you have used in your operations conducted along the lines set forth in answer to XQ-103, and then will you name all of the different kinds of oils or other selective agents used by you in any of your operations whatsoever conducted in your investigations and study of the art of mineral concentration by flotation or by the so-called Cattermole effect?

A. I have used in agitation-froth experiments mostly oleic acid. I have also used in agitation froth experiments cotton seed oil, viscous valve oil, palm oil, lard oil, pinoline, linseed oil, eucalyptus, Texas residue oil, turpentine.

I have used for Cattermole and for flotation and for washing out experiments other than agitation froth, Texas fuel oil, oleic acid, cotton seed oil, crude petroleum, Summer dark oil, a mixture of Texas fuel and paraffin wax, petroleum, a mixture of kerosene and Trinidad asphalt and engine oil.

These are the substances which I can remember.

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130-XQ. I understand from your answer to XQs-126 and 127 that you have never, in your operations along the lines laid down in your answer to XQ-103, obtained any floating mineral-bearing froth when using an amount of oil or other selective agent amounting to more than one per cent. by weight of the ore. In order that there may be no misunderstanding, will you state whether I have understood you rightly?

A. That is my recollection.

131-XQ. It is in evidence that Mr. A. Howard Higgins, in experimenting with the Cattermole process, the object of which I understand to be to form the metalliferous minerals into large granules or aggomerates which will have a stronger tendency to settle in water than the gangue, found that, in operating upon Broken Hill ore containing a mineral content of 50 per cent., when using an amount of oleic acid equal to 6 per cent. on the mineral, which I take it would be something about 3 per cent. upon the ore, he obtained good granules "without much froth," and that, as the perecntage of oleic acid was decreased, more froth was formed. This does not seem to accord with the results obtained by you, inasmuch as Mr. Higgins' statement, which is contained in his report of March 16, 1905, shows that he obtained some froth when using 6 per cent. of oleic acid on the minerals, that is, 3 per cent. on the ore. Have you any explanation to offer for the difference between the results obtained by yourself and by Mr. Higgins?

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A. Mr. Higgins gives an explanation and attributes ie appearance of the little froth to insufficient oiling id mixing with large quantities of air. Of course, is difficult for me to explain the experience of a colague, but I think his explanation is correct. My exriments referring to the Cattermole process usually sted for about ten minutes. But I myself, as far as y recollection goes, have never worked with an ore 50% mineral content, which was the ore that Mr. iggins was working with when performing this exriment.

132-XQ. When, in the treatment of an ore pulp with l, the particles of metalliferous mineral are caused unite into granules or agglomerates, is it your exrience that these built up granules or agglomerates ve a greater or less tendency to sink than do the sepate metalliferous particles?

A. My experience is that when a number of very ie particles of mineral are cemented together into anules, such as happens in the Cattermole process, ey have a greater tendency to sink than do the sepate metalliferous particles. The true phenomenon of ecific gravity comes into play.

133-XQ. In your interpretation of the Froment itish patent, you have given in one instance a definin to the word "spherule," which, as I understand it, scribes the spherule in that instance as an agglomte or mass or granule of oiled mineral particles. these agglomerates, masses or granules, which in

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one instance you have stated the word spherule refers to, correspond to the agglomerates or granules formed in the Cattermole process?

A. I am speaking from recollection. I believe I explained the word "spherule" in two ways. When Froment speaks in paragraph one of his principles that the oiled particles have a tendency to unite in spherules, I explained that he meant that the oil contained in a particle or in an aggregation of particles would unite with the oiled contained in another particle or an aggregation of particles, and that these particles would be combined in the oil, which would form a globule or spherule. In paragraphs 3 and 4 of these principles, he refers to the second kind of spherule, which he calls "metallic spherules," and which one might call "hollow spherules," that is, a bubble of gas, with a layer of oil in which the minerals are embedded.

The spherules referred to by you might be called granules with a much larger amount of oil contained therein.

134-XQ. In your investigation of this subject, did you actually see these different kinds of spherules and granules and did you see them in such a way that you could plainly observe the globules of oil containing sulphides as you have stated in connection with the Froment process, and subsequently see these globules of oil containing sulphides form themselves into an envelope covering a bubble, the wall of which was formed of oil, and did you see all of these things in such a

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ıanner that you are able to testify as a matter of fact s distinguished from opinion or inference that all of ıese things took place?

A. In the Froment process, it is only possible to bserve the spherules which have a bubble of carbonic cid enclosed. It is quite easy to see them rise to the ɔp or the surface. When they land, one can observe ow they press against other spherules and how the il gradually flows into a layer, in which these spherules re embedded. The description of Froment is quite corect. Of the first spherules, Froment only states that hen particles of ore are moistened with oil, they have tendency to unite together. He does not speak of ıe actual production of these spherules. He says this ndency is retarded by the specific weight and opposed y their enclosure within the gangue.

135-XQ. Have you determined, in the case of each the oils or selective agents mentioned in your anser to XQ-129, how much of each of them is necessary form a layer upon the surface of water in a test tube the kind used by you in making a similar determinaɔn upon oleic acid?

A. No.

136-XQ. Is your knowledge as to how much oil necessary to form a layer upon the surface of water a test tube of the kind used by you confined to your termination of that amount in the case of oleic acid, dinary thin lubricating oil and a heavier lubricating , these being the substances mentioned by you in anser to XQ-102?

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A. I believe I tested also cotton seed oil and olive oil, but I will let you know definitely at the next session.

137-XQ. Do you know the composition of the viscous valve oil referred to by you in answer to XQ-129?

A. I cannot give you the composition. It is not a definite chemical compound.

138-XQ. I presume that the substance known in the trade as viscous valve oil is not a definite compound or mixture, but is apt to vary according to the ideas of the different makers. Would you expect to find uniformity in substances known as viscous valve oil?

A. No.

139-XQ. Will you answer my preceding question with reference to the substances you refer to as "engine oil," whether this substance, known as mineral engine oil, is one of uniform composition or whether you would expect it to vary when obtained from different sources at different times?

A. I should not expect this substance to be a definite chemical compound. It is required to possess certain physical properties suitable for the uses to which it is put.

140-XQ. What is pinoline?

A. Pinoline is a hydrocarbon belonging to the turpine series. It is a very thin oil. The name comes from pine trees and it is a vegetable oil.

141-XQ. Is pinoline made commercially from pine wood?

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A. Yes, from pine trees; I think that is the chief source.

142-XQ. How is it prepared; by distillation?

A. I think so.

143-XQ. Is pinoline one of the substances included under the term "wood oil?"

A. I should call it rather a turpine.

144-XQ. What is the substance commercially known as "tar oil?"

A. Tar oil is a result of the destructive distillation of coal. It contains a number of substances.

145-XQ. Are you familiar with a tar oil derived from wood?

A. Yes.

146-XQ. And how is wood tar oil made from wood?

A. It is obtained by the destructive distillation of wood and contains a number of substances.

147-XQ. Are pinoline and wood tar oil products obtained at different stages in the destructive distillation of wood?

A. No, not pinoline.

148-XQ. Are you acquainted with any of the uses of wood tar oil?

A. My knowledge is more intimate of coal tar oil, but I can give you a number of substances which are prepared from wood tar oil. I believe acetone and acetic acid are obtained from it, and I believe we have to rely on the United States for a supply of acetic acid which is obtained from this oil. It is shipped from there in enormous quantities as acetate of lime.

149-XQ. Do you know any of the uses to which wood tar oil itself is put?

A. No, except as appears in this evidence.

150-XQ. Do you know whether wood tar oil is the substance used for oiling the ropes used upon ships?

A. I do not know of this use.

151-XQ. Have you ever attempted to ascertain how much wood tar oil is necessary to form a layer upon the surface of water in a test tube of the kind used by you in making your similar determination with regard to other oils mentioned by you?

A. I have not, but if you would like to know, I will do so.

Adjourned to Wednesday, November 13, 1912, at 10:30 in the forenoon, at the same place.

New York, November 13, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Cross-examination continued:

152-XQ. If you were to attempt to apply the Froment process of his British patents to the ore described under the heading "Example 1," set forth in the patent, would you add limestone to the ore?

A. No, I should not.

153-XQ. In operating upon any ore containing a

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sufficiency of a carbonate, would you, in applying the process of the Froment British patent, add a carbonate thereto in addition to that naturally occurring in the ore?

A. It all depends on the nature of the carbonate. If, for instance, sodium carbonate were present, I should wash that out and not use it. If there were rhodochrosite present, I should add limestone. It must be limestone or a carbonate which on a test would show the same qualities. I cannot answer the question with yes or no.

154-XQ. Is a quantity of oil approximating the amount you have named 12½ per cent., necessary in the practice of the process of the Froment British patent to secure the floating matter in the form that you have described, that is, in the form of a magma as you have defined a magma?

A. I cannot answer that question. I tried the test tube example with three oils, which are referred to and which have been used by Dr. Byrnes, namely, cotton seed oil, olive oil and oleic acid and also mineral oil, and I tried them in quantities which were necessary to form a layer. I have estimated the quantities necessary. They are slightly higher for cotton seed oil, a little lower for olive oil, and somewhat lower for a rather thin lubricating oil than the 12½ per cent. found for oleic acid. I followed the instructions of the example, and made no variations.

155-XQ. Then I understand you made no attempt

to find the least or most economical quantity of oil that, in the practice of the process of the Froment British patent, would form what you have defined as a magma?

A. I said in reply to one of the previous questions that my investigations were concerned with the alleged anticipations and with the process of the patent in suit. I did not attempt to improve any of the processes of these documents by applying knowledge of to-day. I tried to work them as well as I could with the knowledge existing at the time of their discovery, using such knowledge as a competent man might have had at the time. I made no experiments varying the quantities of oil with regard to the Froment test tube example.

156-XQ. Then I take it that you are unable to testify regarding what is the smallest and most economical quantity of oil that, in the operation of the process of the Froment British patent, will produce the phenomenon which you have described as being a magma? Is this correct?

A. That is correct. If you think it is of assistance to the Court that such an investigation should be made, I am quite willing to do it. It did not appear to assist me in the interpretation of the invention of Froment.

157-XQ. You have said that the principle involved in the operations described in the Froment description referred to in Q-33, "is skin flotation assisted by bubbles of carbonic acid." Does this skin flotation assisted by carbonic acid bubbles result in the floating products which you have described in connection with the operations of the Froment British patent?

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A. No. The result of the instructions is purely skin flotation, assisted and induced by attachment of carbonic acid bubbles to the oiled minerals. It is not like the magma as I have seen it in the test tube example of the Froment patent.

158-XQ. What is your conception of a process, that is, a technical process of the general type now under discussion by us?

A. From my knowledge of what has been applied as a technical process to the ore concentration industry, there is as a type the Elmore process, that is, oil buoyancy flotation by reduction of the specific gravity of a mixture of a heavy oil with minerals to such a degree that it is lighter than water. The second process which has been found practical is the Cattermole process, the phenomenon of which is the increase of the falling power of oil agglomerated minerals to such an extent that the falling power is much greater than the falling power of the gangue. The third process is the process of the patent in suit, which, in consequence of its incredible economy, has superseded the two previous processes. My conception of a technical process is, I am speaking now of the present day, a process which is at least as economical as the agitation-froth process, whilst, at the same time, giving at least the same return.

159-XQ. Please give your definition of the word process.

A. A process is one or a number of operations car-

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ried out with certain materials for the production of a certain result.

160-XQ. Is the process set forth in the Froment description the same process as that of the Froment British patent?

A. The process revealed in the instructions differs essentially from the process as revealed in the test tube example of the Froment patent, and it differs in essential points from the process which is not described in the Froment patent but which I said might be inferred from the general description and from the claim. One of these is a de-sliming operation which is necessary, according to the instructions; but that is only one.

161-XQ. You refer to the Froment description as recommending that the concentrates be subjected to high pressure in a hydraulic or filter press for the recovery of the oil. Do you think this would be a practical operation as applied to the concentrates obtained according to the process of the Froment description?

A. It is quite a feasible process and a sound one, if my recollection of the instructions is right. Froment says that it is the custom in the Latin countries, that is, Italy, Spain and France, to treat ores of a low mineral content. If you have an ore, say, containing 5 per cent. of a metal, of which, however, I believe that it is scarcely ever done with certain metals such as zinc or lead, in other countries, the concentrates would contain about 15 to 16 per cent. of oil, and part of that could be recovered. In many cases, perhaps a recovery could not

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be effected of the oil, but Froment tried in his instructions to provide for all emergencies.

162-XQ. Now, referring to the operation set forth in the paragraph following the paragraph numbered 4 in the complete specification of the Froment British patent, would it not be the case that, if a poor ore were operated upon, for instance, an ore containing about 5 per cent. of blende or copper sulphide, and an amount of oil were used equal to 1 per cent. upon the ore, contrary to your interpretation regarding the amount of oil, the concentrate obtained would contain a comparatively large amount of oil, an amount capable of separation in a filter press as stated by you in connection with the process of the Froment description?

A. My answer on your assumption is, yes, provided there are no other minerals of the type present, which nearly always are in copper ores, and assuming that all the oil was in the concentrate and no gangue.

163-XQ. In your answer to Q-32, you state that Froment says, in his Italian patent, "when a gas is generaed in this mass, etc.," certain things will follow. Will you please state what words occurring in the Italian patent you translate by the use of the English word "generated"?

A. Se degage. I could not think of another translation.

164-XQ. Is not the French verb "degager" of broader significance than the English word "generate," using the word generate as confined to chemical action, and

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is there not another word in the French language which would ordinarily be used to represent the idea of generation of a gas by chemical action alone?

A. As I understand the meaning of the word "se degage" it can only mean generated. There is another word in the French language which means the same, namely, generated. I think the other French word is "engendrer," but I am not quite sure about it.

165-XQ. Are the English words "disengage" and "liberate" equivalents of the French verb "degager"?

A. I think that is correct.

166-XQ. You have attached different meanings to the word "spherules" as used in the paragraph numbered 1 and the paragraph numbered 4 of the complete specification of the Froment British patent. I invite your attention to the fact that, in paragraph 4, the metallic spherules are referred to as "these metallic spherules." Does not the use of the word "these" show that in paragraph 4 Froment is referring to the same spherules previously mentioned, namely, those referred to in paragraph 1? In this connection, I also invite your attention to the fact that, in the Italian Froment patent, the expression "ces spherules metalliques" is used.

A. My reading is that "these metallic spherules" refer to paragraph 3, namely, to "the bubbles of the gas become covered with an envelope of sulphides," and not to the "spherules" mentioned in paragraph 1.

167-XQ. You state, referring to the Froment op-

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erations described in his British patent in the paragraph following the paragraph numbered 4, that the calcite is present only as a source of carbonic acid, yet Froment uses for the decomposition of one gram of calcite only a few drops of sulphuric acid. This would show, would it not, that in the test tube operation Froment did not decompose all of the gram of calcite used?

A. The expression "a few drops" is very loose language, no doubt. It is reasonable to assume that he poured the acid from a bottle and the drops would be thus larger than the drops, say, from a pipette or a burette. Then again, "a few drops" is nothing definite. I should say the measure for the acid would be the quantity of calcite or limestone which he specifies. That enables the metallurgist to use a quantity which gives him all the benefit that can be derived, namely, the full quantity of gas contained in the limestone. With a few drops of sulphuric acid, he probably has some of the limestone left unattacked.

168-XQ. In most localities I believe you have said that limestone is a comparatively cheap and common substance. At any rate, this is so, is it not?

A. That is so.

169-XQ. And, as compared with limestone, sulphuric acid is quite an expensive substance, is it not?

A. I cannot tell about the price of limestone. The price of a ton of sulphuric acid, the ordinary brown oil of vitriol, I believe is 25 shillings, or about $6.00.

170-XQ. Assuming that limestone is cheaper than

sulphuric acid, would not a convenient mode of generating a desired amount of carbon dioxide be to use an excess of limestone and to regulate the amount of carbon dioxide by the quantity of acid used, and would not the consumption of the entire amount of acid be more nearly effected by providing an excess of limestone over and above the precise amount necessary for reaction with the sulphuric acid?

A. Your question is not confined to any specific utilization of the carbon dioxide. As a general proposition for the production of carbon dioxide to be collected, it would be advisable to add the sulphuric acid gradually but you still must have the full amount of acid to get the full benefit from your limestone; but sulphuric acid is scarcely ever used for the purpose. In a laboratory, if I wanted to generate a desired amount of carbonic acid, I should take the quantity of limestone which could furnish it and I should take a slight excess of acid to generate it. That is the usual practice, and the most convenient way of doing it. You may easily leave a portion of the acid unused if you have not an excess present, and if you want to get a desired quantity, you ought to have an excess of the acid over the limestone. If you have an excess of limestone over sulphuric acid, there is no reason why the sulphuric acid should not be consumed, but it would not be any more nearly effected by providing an excess of limestone. But I disagree with the first part of the question, it would be a wasteful mode as the excess of

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limestone would be wasted, and as there is no necessity for it.

Adjourned to Thursday, November 14, 1912, at 10:30 in the forenoon, at the same place.

New York, November 14, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Cross-examination continued:

171-XQ. In performing the operations set forth in the paragraph of the British Froment patent following the paragraph numbered 4, would not a reduction of the quantity of carbonate used, in pursuance of Froment's caution that there is a proportion to be sought for a given ore and limestone, lessen the quantity of carbon dioxide evolved and thereby prevent the evolution of so much gas as to project the contents of the test tube therefrom?

A. A reduction in the quantity of limestone would necessarily reduce the quantity of gas, namely, carbonic acid, if as I have stated to be my understanding, the quantity of limestone is the measure of the quantity of sulphuric acid to be used. If there were an excess of limestone over sulphuric acid, then there need not be a reduction in the quantity of carbonic acid produced.

172-XQ. You have stated that, according to your in-

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terpretation, the agitation directed by Froment in the specification of the British patent is for a very short period, as practised by you from two to seven seconds, and you state that agitation for such a short period must be advice to generate the carbonic acid as quickly as possible. Will you state how the very short period of agitation would have the result of generating carbonic acid more rapidly than a longer period?

A. It is well known to chemists and metallurgists that in such operations as the action of sulphuric acid on limestone, the evolution of carbonic acid gas is instantaneous if you operate in such a manner that you bring the whole of the limestone into intimate contact with the whole of the acid. Froment directs an operation lasting in all its phases for a few seconds and that clearly is advice to metallurgists that he wants practically instantaneous evolution of the carbonic acid. A longer period of agitation, in view of Froment's description and instruction in the patent, would not only be contrary to Froment's instructions, but would be utterly useless. Froment wants to make use of the carbonic acid in the nascent state and that he can do only by operating in the way as described. A longer agitation would destroy all the benefits which he derives from the gas in its nascent ~~taste~~ state. I answer, therefore, Froment directs the short duration of his whole process because he knows that the evolution of carbonic acid from limestone by sulphuric acid is instantaneous and he wants the use of the carbonic acid in its nascent state

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as, according to his researches, this condition of the gas is highly beneficial to this process. A longer agitation would defeat this object. I did not state that a short period of agitation would have the result of generating carbonic acid more rapidly than a longer period, but I said it is advice to generate it as quickly as possible, that is, by bringing quickly all the calcite into contact with the acid.

173-XQ. If it were Froment's desire to generate the carbon dioxide as rapidly as possible by securing as quickly as possible contact of all the acid with all the limestone, this would indicate, would it not, according to your reasoning, that the agitation should be of as violent a degree as possible?

A. That does not necessarily follow. A comparatively gentle agitation will keep finely powdered limestone in suspension.

174-XQ. You state that one may infer from the words occurring in the Froment British patent "the formation of the spherules and their separation from the gangue" that the patentee contemplates first the production of oiled minerals heavier than water and buried in gangue. In view of the test tube operation described by Froment in his British patent, would it not be more reasonable to interpret the expression quoted as meaning that the separation of the spherules from the gangue takes place while both the gangue and metalliferous mineral are in suspension in the water?

A. No, I cannot even imagine such a meaning. I

submit that the inference which I drew is the more reasonable one. But I will say that the Froment document is in a great many respects a puzzling document and leaves a great deal to the individual imagination with which a reader is endowed.

175-XQ. In your answer to Q-32, you quote the claim of the Froment British patent, following which you make a statement which I understand to mean that the claim does not set forth the same process as that involved in the test tube operations described by Froment. I am unable to understand exactly what difference you intend to point out between the process of the claim and that of the test tube operation. Will you kindly state whether I have understood you rightly, and, if so, will you state precisely the difference between the process of the claim and that involved in the test tube operation?

A. I read the claim in the following way: Add the ore to the water, mix; add a suitable oil; mix; add an acid to liberate a gas in the mixture. That seems to me a reasonable explanation of the claim and it satisfies me to a great extent as a chemist, but I confess again that the claim is a very general statement and it must be read to have the meaning which I gave in connection with the several parts of the document from which I have drawn a similar inference. But I am sure that the claim cannot refer to the test tube example.

176-XQ. In your answer to Q-33, you refer to that part of the Froment description which recommends the

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addition of 1 to 2 per cent. of carbonate of lime to the ore. Is not this an amount of carbonate of lime, that is frequently found in ores as a natural constituent thereof?

A. A carbonate of lime is very often found present in ores. The amounts vary.

177-XQ. In answer to Q-33, you state that there is no necessity for the pipe for admission of steam to the Froment apparatus, except for cold countries, and that the steam pipe is only provided to prevent the freezing of the plant. Does Froment state this purpose for the steam pipe in his description?

A. In his instructions he states that the use of steam

"is only necessary in cold countries."

178-XQ. Does Froment in his description say anything about the steam supply being provided only to prevent freezing of the plant?

A. Not in these words.

179-XQ. If the Froment plant were to be used in a locality where the temperature of the water used was only a degree or two above the freezing point, I understand it to be your interpretation of the Froment description that the steam supply was not contemplated for the purpose of raising the temperature of the water to such a point as would be conducive to the production of the result set forth in the Froment description. Is that correct?

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A. No, I should not put such a narrow construction on it. Froment clearly intends his process to be used at normal temperatures such as they occur in the moderate climates of Europe. If the temperature were such as you say, it might be reasonably presumed that he might have used the steam for heating up his water to normal temperature. Of course, it is quite well known to every metallurgist that the action of carbonic acid is equally energetic at 2 to 3 degrees Centigrade, as at 15°, and I, therefore, said, as I think quite justly, that he meant to prevent the freezing of the plant by the use of steam.

180-XQ. In the document which has been introduced in evidence as Sulman and Picard Report of May 3, 1905, I find the following statement:

> "This upcurrent tends to keep the fine sands product free from gangue slimes and also to prevent the falling of any mineral flocks from the float froth traveling over it, or to return such flocks again to the surface."

Will you define what these flocks are and what leads to their formation in the practice of the process of the patent in suit, this being the process, as I understood it, under discussion by Messrs. Sulman and Picard in their report of May 3rd, 1905, referred to?

A. The word "flock" does seem to be used with a number of meanings but Mr. Sulman in his evidence makes it quite clear what he means by it. I quote from

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his answer to Q-110 on page 261 of Defendant's Record:

"The slime mineral particles appear to be closely associated with each other and with the larger particles, at times, in the form of spongy flocks, the whole mineral being so intermixed, as regards its varying sized particles and flocks and with the air bubbles as to form coherent froth of somewhat spongy nature. The nature of the froth varies somewhat with different minerals, but all have the same specific matter, coherent and persistent characters when the plant and process are operated to their best purpose and effect. The froth so obtained when broken down by mechanical means or by draining results in a deposit of the mineral particles, which exhibit to the touch and upon inspection, no visible traces of oil, and one would not suspect the presence of oil therein unless an analysis were made. One essential for such a froth is the inclusion therein of slime mineral, as without the aid of such fine material our experience is that the specific agitation froth we obtain normally cannot be formed."

I quote further from the report referred to:

"Should any slight amount of froth sink during this floating off process, a slight stirring by hand of the contents of the mixer will at once bring to the surface any such particles of sunk froth."

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It is clear that Mr. Sulman, in the passage of his report quoted in the question, calls such parts of the froth which might sink during the floating off process, flocks, as the froth which had sunk presented probably such an appearance. He described in his testimony which I quoted that the froth appeared to him like "spongy flocks," and I quite agree with this description of the froth. On looking at the agitation froth, it presents an appearance like a sponge and it is quite correct to say that it is a coherent froth of somewhat spongy nature. I understand that the flocks referred to in the question are the "slight amount of froth" sunk "during this floating off process."

181-XQ. Referring to the sentence which you quote in your preceding answer from Sulman and Picard's report, May 3, 1905, how would you understand that the "slight stirring by hand of the contents of the mixer" was to be performed; I mean, by a spatula or rod or what would you consider would come within the expression referred to?

A. I understand that the mixer, or rather the belt which served for turning the mixer, was moved by the hand instead of by the electric motor.

182-XQ. In any of your experiments in flotation by the use of oil, have you observed any tendency for flocks of minerals to sink instead of remaining upon the surface?

A. The term "flocks," as I said before, does not convey a distinct meaning. It has been used by Mr. Sul-

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man in the sense explained by me. It has also been used to denote an aggregation of particles in oil. I have seen little parts of a froth fall to the bottom and I have also seen aggregations of particles in oil fall to the bottom. As a rule, however, aggregations of particles in oil are at the bottom.

183-XQ. In your investigations, how have you found the degree of agitation necessary in what you term the agitation-froth process to compare with the degree of agitation necessary in the first stage of the Cattermole process, it being my understanding that, in the Cattermole process, there are two stages of agitation, the first comparatively violent for the purpose of distributing the oil over the metalliferous particles, and the second stage being more gentle or more in the nature of a mass rotation of the pulp, rather than an agitation that would impart great turbulence to it?

A. It has been stated in this evidence that to obtain larger and firmer granules, the second agitation in the Cattermole process might be varied. But that is not necessary and as I understand the patent, the patentee leaves the use of a variation of the second agitation optional. I have carried the process out in two ways; in one way, I used the same agitation for both operations; in the second way I removed the baffles from the cone mixer and got a different form of agitation. The granules produced by the latter experiment were larger than the ones produced by the former agitation. The determination of the agitation suitable for the pro-

cess of the patent in suit and for the process of the Cattermole patent is very simple. Cattermole requires an agitation which is sufficient to oil the mineral particles. The patent in suit requires an agitation which is sufficient to oil the particles and to draw in air and beat it up in a fine enough form so that it can commingle with the oiled particles. I am speaking from memory now. I believe that 500 to 600 revolutions are quite sufficient for the Cattermole process. But I believe that at least 1200 revolutions per minute are necessary for the process of the patent in suit, in the same apparatus. That is easily determined by a simple experiment. Cattermole also has much larger quantities of oil as compared with the patent in suit, which again requires less agitation.

184-XQ. The number of revolutions which you have referred to in your preceding answer relates to the small apparatus or to the large apparatus used in commercial practice?

A. The number of revolutions relates to the small apparatus. I guarded myself by saying I was speaking from memory. It has been often mentioned in these proceedings that there were two small apparatus used, one called the slide machine, and the other the cone mixer. They are both of the same size about. I am definite about the number of revolutions referring to the Cattermole experiments, but I am doubtful whether I did not use a higher speed for the agitation-froth process in the apparatus used for the Cattermole pro-

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cess when using it for the agitation of the patent in suit. I will, however, give a definite answer tomorrow.

185-XQ. Do you agree with the statements made by some of the witnesses in this suit to the effect that the correct mode of estimating the degree of agitation is by reference to the peripheral speed imparted to the agitator, rather than by reference to the number of revolutions per minute of the agitator?

A. Given the same kind of apparatus, the peripheral speed is the chief determinant of the degree of agitation.

186-XQ. With a given number of revolutions per minute, the peripheral speed imparted to an agitator would be proportional to the diameter of the agitator, would it not?

A. The formula to determine the circumference of a circle is d. w. d. meaning the diameter of the circle, and w. meaning a constant. You are quite right. The speed of the periphery of a larger agitator is in proportion greater to the smaller one in the same way as its diameter differs from the diameter of the smaller circle.

187-XQ. That is, stated in another way, at the same number of revolutions per minute an agitator having a diameter of 2 feet would have twice the peripheral speed of an agitator having a diameter of one foot?

A. I agree, and I add that counsel has put it in the most admirably logical and simple way.

188-XQ. In your answer to Q-34, you made the following statement.

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> "The conclusions from these experiments are that it is impossible to produce the Froment result with the proportions between ore, oil and acid which Dr. Byrnes used in the slide machine experiments described on pages 165 and 166 of Defendant's Record, and I say deliberately that it is impossible with such proportions to produce the Froment result of the test tube example, namely, causing the whole of the mineral to rise instantly to the top of the liquid in the form of a magma. It is obvious and self-evident from the result of these experiments that Dr. Byrnes' experiments cannot be in accordance with and are not the invention revealed in the Froment patent."

Do not the experiments performed by Dr. Byrnes, regardless of whether you consider them Froment operations or not, show that a froth can be produced using quantities of oil largely in excess of the quantities specified in the patent in suit?

A. I have myself not made such an experiment and I am not speaking from personal experience. I am of opinion, as I stated, that if a froth is produced with quantities of oil such as are used in four of the five experiments, it must lack some of the characteristics of the agitation froth; that is, for instance, it would not show the metallic lustre and would be oily. Dr. Byrnes says he has produced a froth with a large quantity of oil. If it is produced, it is not produced by the Froment

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process, but by the process of the patent in suit. A froth such as can result from the quantities of oil used in four of the experiments would be valueless for the reason of its great expense.

189-XQ. Will you state whether you have determined how much wood tar oil is necessary to spread over the surface of water in a test tube of the kind which you have used in your investigations, and, if so, will you state what the quantity is?

A. I have procured a sample of wood tar oil. It did not form any layer on water. It sank to the bottom because it is specifically heavier than water. If I had been thinking carefully, I would have been able to answer the question before. In the destructive distillation of wood, a distillate is obtained which consists of three layers, the bottom layer is a wood tar oil, the medium layer is an aqueous solution of acetic acid, and the top layer is a solution of methyl, alcohol and acetone. This is a recollection of my earliest student days.

190-XQ. In experimenting with the wood tar oil, did you try dropping the oil upon the side of the test tube and letting it run down on the surface of the water, or did you try in any other way to deposit the wood tar oil gently upon the surface of the water, and, if so, did you not find that one drop of the wood tar oil would spread over the entire surface of the water and form a layer thereon?

Adjourned to Friday, November 15, 1912, at 10:30 in the forenoon, at the same place.

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New York, November 15, 1912.

Met pursuant to adjournment.
Present—Counsel as before.

Cross-examination continued:

A. I dropped some wood tar oil which I used in the middle of the test tube and it went down. I tried the experiment suggested in the question. When pouring it down the side of the test tube, it stuck and would not form a layer. To reduce the viscosity I warmed it, and repeated the experiment. It did not form a layer, but slid down the glass wall and went to the bottom.

191-XQ. My question related to wood tar oil and I now ask you whether you have ever deposited upon the surface of water in a test tube a drop either of the substance commercially known as pine tar oil, a drop of turpentine, a drop of a mixture of turpentine and a fatty oil, in the proportion of fatty oil from 10 to 25 per cent. of the tar mixture, the latter being the proportion mentioned in the United States patent to Robson, or to Robson and Crowder, as it has been referred to in this record, No. 575,669, or a drop of pine oil or pinoline, or a mixture of pine tar oil and a fatty acid, or a drop of crude eucalyptus oil, or of refined eucalyptus oil, and also ask you whether you did not find that, in the case of most of these oils or mixtures, a single drop would form a layer covering the entire surface of the water in the test tube.

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A. The wood tar which I used was procured here and is called American pine wood tar. I called it wood tar oil because it is usually called that way. I sent out to procure Stockholm wood tar, which is a very well known product, and of which I know it has been used in the process of the patent in suit. I have tried none of the other oils mentioned in the question with the exception of eucalyptus oil, and I say that one drop does not form a thin layer.

192-XQ. Did you ascertain how many drops of eucalyptus oil would form a layer upon water in a test tube?

A. The quantity required of eucalyptus to form a layer which could be seen was .225cc. I give these second and third decimals as a guess. It was between .2 and .25cc. This quantity is giving you the lowest possible quantity which would be called the thinnest possible layer.

193-XQ. Is the wood tar referred to by you in answer to XQ-191, a different substance from that sold commercially as pine tar oil?

A. I could not say.

194-XQ. Will you, for the information of the Court, upon this matter which you have discussed as to the amount of oil necessary to make a layer on the surface of water in a test tube, ascertain how much of each of the substances referred to by me in XQ-191 is necessary to form a layer upon the surface of water in a test tube of the kind used by you previously, and, in

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the case of those substances which have a greater specific gravity than water, will you make your determination by depositing the oil gently upon the surface of the water, as may easily be done and naturally would be done by dropping the oil upon the side of the test tube and letting it run upon the surface of the water? If requested, I will furnish you with the substances referred to or direct you to dealers where these substances may be purchased in any quantity.

By Mr. Williams: Timely objection is here made to the present and preceding question as calling for matters utterly irrelevant to the issues herein.

By Mr. Scott: While not desiring to make any argument at this time, the attention of the Court is invited at this point for the purpose of convenience, to the elaborateness with which the quantity of oil necessary to form a layer on water in a test tube has been discussed by the witness in connection with the instructions of the Froment British patent to use "a thin layer of ordinary oil". In view of the facts shown by the record no explanation of the relevancy of the question is necessary.

By Mr. Williams: Defendant's case is closed. Defendant's expert has given his views of the Froment patent. No foundation was laid in that testimony for the view that any of the materials mentioned, such, for example, as turpentine, were the

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"ordinary" oils referred to by Froment, in his modification of what was known in 1902 as the oil process of ore concentration. The objection that this matter is utterly irrelevant is submitted to be clearly warranted.

By Mr. Scott: Defendant's expert gave his views that a very small quantity of oil was necessary to form a layer. He made no attempt to enumerate the endless number of ordinary oils. The foundation for reference to ordinary oils is in the Froment British patent, and no further foundation for reference thereto is necessary. Defendant's expert, in his experiments, plainly shows that he interpreted the Froment instructions to use a thin layer of oil as signifying that small quantity of oil which one familiar with the physical properties of oils would naturally use. It is submitted that the question objected to is proper, in that it is sought thereby to present the views expressed by defendant's expert from being rebutted by reference to a few selected oils which it has been stated require to be used in an amount equal to 12½ per cent. of the ore in the case of the Froment operations to form a layer. The views expressed by defendant's expert witness should not be subject

P. 833, L. 28, insert " is made to rebut them, that attempt " before " should "

structions rather than by reference to two or three

particularly selected oils. Furthermore, one of the mixtures referred to in the question is a mixture recommended in one of the prior art patents covering an oil concentration process.

By Mr. Williams: Entering with diffidence at this time upon an argument to make clear the reasons for an objection, complainant's counsel merely calls attention to the fact that defendant's expert did not use any of the oils called for or in any manner refer to them in connection with his testimony, and to the further fact, which is perfectly clear from the evidence, that the Robson and Crowder worthless oil washing process was not "what is known as the oil process of ore concentration" in 1902.

A. I have made the tests referring to this question with the ordinary oil, which is clearly described by Froment. I have then applied the same test with the oils which Dr. Byrnes considered to fall under this specification. I have never made an attempt, and I never stated so, to bring a complete investigation of the layers which all the oils could form on the surface of water before the Court. I am quite willing to do so, and will do so if I can. I want to express my thanks for the lesson which counsel gave me in carrying out a very simple operation. I have had thirty-seven years' experience in chemistry and, I say this with great diffidence, my name is pretty well known in Europe. But I

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am always delighted to learn. I shall carry out these tests in such manner, as I have carried out all the tests in this litigation or in any other matter, conscientiously and to give such information to the Court which will be of assistance to the Court and not be misleading to the Court.

195-XQ. Will you state the specific gravity of the eucalyptus oil which you used in estimating the amount necessary to form a layer in a test tube?

A. I do not know it.

196-XQ. Is it greater or less than water?

A. From the result of experiments, I should say that t was less than water.

197-XQ. In your reply to Q-34, you refer to an agiation such as will commingle air with a mixture of ore ulp with a quantity of oil. Would not any degree of gitation sufficient to commingle oil with the pulp in uch manner as to moisten the metalliferous particles lso have the effect of aerating the pulp, that is, the efect of causing the pulp to be interspersed with air bubles?

A. No, not in my experience. To produce the reult of the patent in suit requires much more aeraon than can be obtained by an agitation sufficient to oisten the metalliferous particles of the pulp.

198-XQ. My last preceding question did not call for ny statement as to the amount of aeration required by e patent in suit, but inquiry was simply made as to hether the agitation necessary to commingle the oil

with the pulp sufficiently to moisten the metalliferous particles with oil would not have the effect of aerating the pulp; that is, causing the pulp to be interspersed with air bubbles. Will you kindly answer the question without reference to your opinion as to whether such aeration would be sufficient for the purposes of the patent in suit?

A. The process of agitation required for moistening the mineral particles with oil may, or may not, mix some air bubbles with the pulp, and might conceivably produce some skin flotation.

199-XQ. In view of your opinion as to the amount of agitation or degree of agitation necessary to produce the result aimed at by the process of the patent in suit, would you consider it sufficient to instruct the operator to agitate the pulp containing oleic acid until the oleic acid had been brought into efficient contact with the metalliferous particles of the ore or would you consider further instructions necessary?

A. In carrying out the process of the patent in suit, I should instruct the operator to agitate in such manner that, by the introduction of the air resulting from the agitation, the oiled mineral particles would rise in the form of a froth to the surface. The instructions in the patent are absolutely clear. I assume that your question also includes the other conditions which are mentioned.

200-XQ. In commenting, in your answer to Q-34 upon Dr. Byrnes' experiment described in the paragraph

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beginning at the bottom of page 165 of Defendant's Record, you state that "the concentrates produced on the surface of the liquid are both in appearance and character entirely different from the agitation froth of the patent in suit," and you further state that "the oily character of the minerals is clearly visible to the naked eye." As you have stated that you did not repeat Dr. Byrnes' experiments in the slide machine, will you kindy state what experience you base your quoted statements upon?

A. I have seen many times concentrates produced ven with much smaller quantities of oil than used by Dr. Byrnes, and in each case I found the appearance reatly different from the appearance of the agitation roth. Even quantities as small as 1.5 per cent. alter e look of the mineral particles.

201-XQ. Do you understand the process of the patnt in suit to be a process for the production of a froth aving the appearance and characteristics you have decribed as pertaining to the froth produced by operaons conducted according to the instructions of that tent, as distinguished from a froth having the appearnce described in the pasasges of your testimony quoted XQ-200?

A. I gave my description of the characteristics of e froth of the patent in suit, of such froth which I d produced with quantities of oil which the patentees scribed as suitable and economical. It is a queson for the Court to say whether a froth produced

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with wasteful quantities of oil by the process of the patent in suit is a froth of the patent in suit.

202-XQ. In your answer to Q-34, in commenting upon Dr. Byrnēs' fourth and fifth experiments described by him in the last three paragraphs of page 166 of Defendant's printed record, you state that, upon analysis of the different grades of oleic acid used by Dr. Byrnes, you found the same total quantity of palmitic and stearic acid in each of them. Did you carry your analysis of these substances to such a point as to ascertain whether there might have been other differences between them which could have influenced the results secured by Dr. Byrnes?

A. My answer quoted was not a comment on Dr. Byrnes' evidence with regard to these experiments. I was only stating a fact which I had ascertained by analysis and I stated then that Dr. Byrnes' implied theories about the difference of results was not in accordance with this fact. Commercial oleic acid usually contains only as impurities palmitic and stearic acids, and the analysis is always directed to ascertaining the quantities of real oleic acid whereby also the quantities of palmitic acid and stearic acid are determined. Whether this particular oil contained any other mysterious substance, I cannot tell, and whether such a mysterious substance could have any influence on his results I am also unable to state. My analysis was only directed to ascertain the amount of oleic acid present in the two samples.

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203-XQ. In your answer to Q-35, you state that you have proved definitely that it is impossible to produce aeration according to the test tube experiments described by Froment. Will you explain what this proof is or refer me to your testimony on the subject if you have already set it forth.

A. This statement refers to the statement of Dr. Byrnes contained on page 170 of Defendant's Record, to the effect that,

> "In his test-tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oiling agent also thoroughly aerates the mixture, the fine bubbles of air distributed throughout it, and attaching themselves to the oiled particles, acting with the chemically-evolved gas to float them."

My proof of my statement which you have quoted is n evidence and I add further that, if Froment had had ny conception of such an aeration, he certainly would have stated it and he would not have used the generaion of carbonic acid in a nascent state.

Adjourned to Saturday, November 16, 1912, at 10:30 n the forenoon, at the same place.

Adolf Liebmann.

New York, November 16, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

Cross-examination continued:

204-XQ. Have you made the determination referred to in my questions numbered 191 and 194, and, if so, with what result?

A. I procured the following samples: turpentine, wood tar oil, pine oil and sweet pine oil (pinoline). I made the tests which you desired with these four samples and also with a mixture containing 90% of turpentine and 10% of olive oil, and a mixture containing 75% of turpentine and 25% of olive oil. I made the tests in the way suggested by you and in the way it is usually done. The results were:

The layer of turpentine on water done

In your way required	.175cc.
In the usual way,	.15cc.

The thickness of this layer is 15/1000 of an inch or 0.0151 inch.

The layer of a mixture containing 90% of turpentine and 10% of olive oil done

In your way required	0.175cc.
In the usual way,	0.175cc.

The thickness of this layer is 18/1000 of an inch or 0.0176 inch.

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The layer of a mixture containing 75% of turpentine and 25% of olive oil done

In your way required 0.25cc.
In the usual way, 0.225cc.

The thickness of this layer is 23/1000 of an inch or 0.0227 inch.

The layer of wood tar oil on water done

In your way required 0.225cc.
In the usual way, 0.2cc.

The thickness of this layer is 20/1000 of an inch or equal to ~~0.201~~ 0.0201 inch.

The layer of pine oil on water done

In your way required 0.25cc.
In the usual way, 0.25cc.

The thickness of this layer is 25/1000 of an inch or 0.0252 inch.

The layer of sweet pine oil o~~f~~r pinoline on water done

In your way required 0.15cc.
In the usual way, 0.15cc.

The thickness of this layer is 15/1000 of an inch or 0.015 inch.

I understand now why you recommended the unusual method for doing these tests, namely, by dropping the oil on the side of the test tube and letting it run upon the surface of the water. Two of the oils, wood tar oil and pine oil, are heavier than water and can only be maintained on the surface by surface tension.

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But it is quite easy to succeed to do this by dropping them in. I still think that the ordinary method is the more accurate one.

205-XQ. Did you observe how many drops of these different substances were necessary to constitute the quantities which you have named?

A. I can only give you the number of drops by calculation. As far as I remember, the pipette which I used for dropping into the test tube gave 14 drops for .4cc. That will give for .15cc. about four to five drops.

206-XQ. In your answer to Q-29, in your remarks about the Schwarz patents, you state that "the patentee directs you to aerate the mixture of ore and oil and not the mixture of air, oil and water." I invite your attention to the fact that in Schwarz patent No. 807,-501, page 2, lines 20-24, and in Schwarz patent No. 807,503, page 1, lines 94-100, reference is made to mechanical agitation and the injection of air, steam or gas during the treatment with water. Do not these statements of the patentee modify your interpretation as set forth in the passage quoted in this question from your testimony?

A. No. I quoted the passage from the document (807,503, page 1, lines 94-100) to which you have referred in your question, together with other parts which explain it, and I had the specific part showing that the admission of air, etc., may be continued actually underlined. From the language, it would appear that this part of the process is optional.

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207-XQ. I invite your attention to the following passages occurring at page 2, lines 106-116, and page 3, lines 27-30, of the patent in suit, as follows:

> "The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in which they are submitted to an additional pressure of air or other gas of from, say, one or two atmospheres or over. On relief of such pressure the bubbles of air or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before" (page 2, lines 106-116).
>
> "The whole of the mineral to which air bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth" (page 3, lines 27-30).

In connection with the patent as above quoted, I ask you whether a coherent froth cannot be formed by the liberation of a gas in an ore pulp, as well as by the introduction of gas therein by agitation?

A. I have not given any consideration to this part of the patent. Dr. Byrnes also passed it over. But there is no doubt, and it is well known, that, if you compress air and if it is in contact with a liquid, the amount of air dissolved in water is in proportion to the pressure to which it is exposed. If air is soluble in water at ordinary pressures in the proportion of .02 vol-

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ume per hundred volume of water, the solubility is increased to double the quantity at an over-pressure of an atmosphere, and so on. If that pressure is relieved, the air will be liberated from the solution. I cannot speak as to the froth produced, either to its appearance or to its consistency, as I have never seen it. This operation, namely, compressing the air, must be carried out in a vessel which will stand over-pressure. Such vessels are usually called auto-claves.

208-XQ. I invite your attention to the following passage occurring in "Complainants' Exhibit, Froment Description,"

> "Steam at low pressure arrives through the holes in the coil and assists the reactions."

Does not the .passage above quoted from Froment's description modify your views heretofore stated to the effect that the only purpose of using heat in the Froment process is to prevent freezing or to raise the mixture to normal temperatures, namely, approximately 60° Fahrenheit?

A. It would, if it were standing by itself, but I submit that the next sentence,

> "This is only necessary in cold countries,"

gives the true meaning, namely, that the steam is intended for increasing the temperature which may exist in cold countries to normal temperatures, and that this is the function of the steam.

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209-XQ. Are the concentrates which you refer to in your answer to my question numbered 200, floating concentrates?

A. Both floating and non-floating. The non-floating concentrates were products such as Cattermole; the floating concentrates were concentrates which floated by surface tension and which had been made to float by the introduction of air through pipes. That is what I at present remember.

210-XQ. Will you state what the thick residuum oil was which one of the witnesses in this suit refers to as having been used in the Elmore bulk oil flotation process?

A. The thick residuum oil used in the Elmore bulk oil flotation process is a residue of petroleum. I believe ordinary types are called Winter Dark Oil and Summer Dark Oil.

211-XQ. Can you give some approximate idea as to the cost of this thick residuum oil in different localities?

A. No. I am sorry I cannot help you there.

212-XQ. Can you give any information as to the comparative cost of thick residuum oil and the substances which are sold as mineral engine oil?

Adjourned to Monday, November 18, 1912, at 10:30 in the forenoon, at the same place.

Adolf Liebmann.

New York, November 18, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Cross-examination continued:

A. No. I tried to get the information, but did not succeed. As Dr. Chandler follows me, I am sure he will give you the information.

213-XQ. Did you ascertain the amount of a mixture of pine tar oil and oleic acid referred to in one of my previous questions necessary to form a layer upon water in a test tube?

A. I have made an experiment with a mixture of these oils. The composition of the mixture had not been mentioned by counsel. As I had only a very small quantity of pine tar oil left, I prepared the mixture of 75% of pine tar oil and 25% of oleic acid. The result was:

The layer on water done
In your way required, 0.75cc.

The layer had then not been completely formed, but I had to desist because I had no more oil.

In the usual way, 0.2cc.

These experiments were made in the presence of Dr. Chandler. The result confirms my view that the usual method is the method to be used for such experiments.

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I had overlooked your request to try this mixture of oils as expressed in XQ-191, and when I discovered my oversight, made the tests and called it to your attention this morning.

214-XQ. In those operations wherein you repeated with a test tube and proportions adapted thereto, the slide machine operations of Dr. Byrnes described by him upon pages 165 and 166 of Defendant's printed record, how did you hold the test tube, that is, did you hold the tube in one hand and close it with the other hand?

A. It is very difficult to say what way one proceeds in these mechanical operations. They come naturally to one. I probably used both hands as you suggest.

215-XQ. Test tubes are made of very thin glass and of a quality of glass that will withstand heat without breaking, are they not?

A. They are comparatively thin, and they withstand heat.

216-XQ. You have given the price of crude sulphuric acid, brown oil of vitrol, I think you termed it, as $6.00 per ton? Will you please state the locality where this price prevails?

A. That is the price in England.

217-XQ. I presume it is the price at the Works where the acid is made?

A. It is the manufacturer's selling price.

218-XQ. You have stated that sulphuric acid is scarcely ever used for the generation of carbonic acid

from limestone. Will you state what acid ordinarily is used for this purpose?

A. My answer referred to the laboratory practice. The usual acid is hydrochloric acid.

219-XQ. Do you know whether hydrochloric acid is ordinarily used in the commercial production of carbonic acid?

A. I should say that the ordinary commercial production of carbonic acid would be carried out by the burning of charcoal. When the carbonic acid is used for the purpose of food as in carbonated drinks, it is usually produced from pure bicarbonate of soda and tartaric acid.

Cross-examination closed.

Re-direct Examination by Mr. Williams:

220-RDQ. In your answer to 184-XQ, you said you were not very definite as to the number of revolutions per minute which you had used when producing the agitation froth of the patent in suit in the cone mixer, and that you would later give definite information as to this point. Please now do so.

A. I have used the cone mixer at a speed of 1200 revolutions and also at a speed of 1600 revolutions for that purpose.

221-RDQ. In describing two tests made by you in carrying out the second process disclosed in the Everson patent, you have given the amount of oil used in cubic centimetres. For the information of the Court,

P. 849, L. 10, insert " second process described in Everson's patent for the " before " ore "

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lease compare these quantities with those specifically et forth in the Everson patent.

A. There is no ore specified in Everson's second example. I assume that she treated an ore of the kind ientioned in her patent, namely, an ore containing ither gold, silver or copper, which she calls, "precious ietals," clearly not in the ordinary chemical sense, but r the reason of their great commercial value. I uld, therefore, not draw any conclusions from the ore used. The apothecary's measure "fluid drams" was ot known to me, but I satisfied myself about it, and ie quantities of oil used in my two experiments are in ccordance with the quantities of the example. My iief guidance, however, for the second Everson mode operation was the fundamental condition which she ecified, namely, that the mixture of oil and mineral iust be lighter than the gangue. The specified weight the mixture of oil and mineral of the first example is 1.8, the specific weight of the gangue 2.5; the ecific weight of the mixture of oil and mineral of te second example was 1.7, of the gangue 2.5.

222-RDQ. In describing tests made by you in accrdance with the Froment description, you said that, i one instance, as to the experiment numbered 2, the nnerals as they appeared on the surface had the look o a magma, and that in another instance, as to experiment numbered 3, the concentrate rose in the form o a magma to the top of the liquid. In other parts of yir testimony you said that the result of the test tube example of the Froment patent was a magma consisting

of oil, gas bubbles and mineral, while the result of the process revealed by the Froment instructions was skin flotation assisted by gas bubbles. Have you anything further to say as to this?

A. In describing the result of the test made according to the instructions of Froment, I said that it looked like a magma, and it is true. Nevertheless, I did not intend to describe it as a magma. It is very difficult to draw the line between a thick mass of heavily oiled particles and floating oil containing mineral particles. The statement which I made that the result of the test tube example is a magma consisting of oil, gas bubbles and mineral, and that the result of the process revealed by the Froment instructions is skin flotation assisted by gas bubbles, is quite correct.

223-RDQ. The specifications of the Froment Italian and British patents state that the oil used in the test tube example is "ordinary oil." Please note that the Italian specification is dated May 20, 1902, the British provisional specification, which repeats this statement, was filed June 4, 1902. The British complete specification, which again repeats this statement, was filed March 4, 1903; also that the British complete specification states:

> "This invention has reference to the concentration of metalliferous ores and earths for the purpose of separating and recovering therefrom the finely divided metal or metallic compounds, and

consists of a modification of what is known as the oil process of ore concentration."

So far as possible returning to the conditions existing at the dates referred to, please state what, in your opinion, was the oil described by Froment in his patents as "ordinary oil."

A. The ordinary oil which is to be used according to the Froment patents, can only be the oil which was used for the Elmore process, namely, a thick viscous mineral oil. Froment's specification says that his process is a modification of the process which was then known as the oil process of ore concentration. There was only one such process known, namely, the Elmore process, and for this process a thick viscous oil was a necessity. The "ordinary oil" mentioned by Froment clearly refers to such an oil. Oleic acid is not possible for Elmore's process. The oils and oil mixtures referred to in XQ-191 are non-viscous oils, quite unsuitable for the Elmore process and this is equally true of the thin mineral oils which I tested. Two of the oils mentioned in XQ-191 namely, wood tar oil and pine oil, are heavier than water and cannot reduce the specific weight of the minerals below the specific weight of water. Normally they are at the bottom of the water. The quantity of a heavy viscous oil, such as Elmore used, necessary to form the thinnest layer is 14.4 per cent. on the ore.

224-RDQ. You have given figures for the smallest

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amount of oil to form the thinnest possible layer in a test tube such as Froment describes. What, in your opinion, is described in the Froment Italian and British patents as "a thin layer" giving your answer, in the dimensions of the thickness of the layer?

A. The term "a thin layer" of oil, used by Froment, is not definite. He does not say a few drops or the thinnest possible layer. I should say that a thin layer of oil, as expressed in the Froment specification, does not mean a layer of less than one-eighth of an inch thickness, but might mean more than that.

225-RDQ. In your tests in accordance with the Froment directions or instructions, it appears that you used an ore which had been crushed through a 60 mesh screen. I call your attention to the specific directions as to crushing which appear in the Froment description under the heading "B Instructions." Please state whether or not the fineness of ore used by you was in accordance with such specific instructions.

A. The standards mentioned by Froment are not known to me. The ore which I used was crushed by step crushing in such a manner that, whilst the minimum of slimes was produced, there was at the same time a proper release of the minerals from the gangue. It will be remembered that it is necessary to de-slime for the practice of the Froment process revealed in the instructions.

226-RDQ. What would have been the result if you had ground the ore to, say, 80 or 100 mesh?

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A. The result of such a grinding would have been a loss of about 50 per cent. or over 50 per cent. in slimes. The crushed ore has to be de-slimed, and it is to the interest of this process to avoid an excess of slime but yet to crush fine enough to release the gangue from the minerals.

227-RDQ. You say there would have been a loss of about 50 per cent. or over 50 per cent. in slimes. Would this be gangue slimes or valuable mineral slimes or both?

A. I should say it would be both.

228-RDQ. And as a general rule, what would be the proportion of valuable minerals in the slimes lost as compared with the proportion of the valuable minerals in the de-slimed ore?

A. I should say the proportion of mineral in the slimes would be about the same with the proportion of mineral in the ore.

229-RDQ. Where did you procure the samples of the oils, pinoline, pine oil and wood tar oil, and the sample of turpentine used by you in your tests described in answer to 204-XQ?

A. I procured the samples at one of the places named to me by defendant. I did not analyze them.

Re-direct examination closed.

Deposition closed.

Adol~~ph~~f Liebmann.

Adjourned subject to agreement of counsel, or new notice.

854 Charles F. Chandler.

New York, December 9, 1912.

Met pursuant to agreement of counsel.
Present: Counsel as before.

Mr. Williams: The following documents are offered in evidence and each entitled "Complainants' Exhibit," followed by the words with which they are described in the following list:

British Patent 7803 of 1905;
Hoover Patent 953,746;
Hoover Patent 979,857;
Gabbett Patent 444,345;
British Boulton & Gabbett Patent 840 of 1889;
British Patent Haynes 488 of 1860;
Hebron Patent No. 474,829;
Robson Patent 575,669;
Cattermole Patent 763,259;
Cattermole Patent 763,260;
Wolf Patent 787,814;
British Patent Chapman 17,328 of 1906;
British Patent Minerals Separation, Limited, and Nutter, 23,870 of 1910;
British Patent Nutter, Hoover and Minerals Separation, Limited, 23,949 of 1910.

CHARLES F. CHANDLER, recalled as a witness in behalf of complainants, having been duly cautioned and sworn, testifies as follows:

Direct-examination by Mr. Williams:

122-Q. Are you the same Charles F. Chandler who has heretofore testified as a witness for the complainants in this suit?

A. I am.

123-Q. Have you read all the testimony in the present suit?

A. I have.

124-Q. Please now give consideration to all documents which have been referred to as prior to the date of invention of the patent in suit, assuming that date of invention to be April 12, 1905, the day of the filing, with provisional specification, of the application for the British patent corresponding to the patent in suit, No. 7803, dated April 12, 1905. Please give first a classified list or summary of these various documents and thereafter briefly consider them in the order of their classification.

A. In summarizing the various documents, I have taken as my basis the summary made by Dr. Liebmann and printed in Complainants' Record, pages 533-536 and 543-545.

Dr. Liebmann separted the documents put in evidence by the defendant and referred to by defendant's expert, Dr. Byrnes, from those put in evidence by complainants

as affording further examples of the efforts to solve the problem of ore concentration prior to the date of the invention which forms the subject matter of the patent in suit.

I have combined in one classified list all of these documents and have added to the list certain other documents so as to make a complete summary of the alleged prior art.

I have also given the dates of the various documents and I note that one of them, the application for the Schwarz patent, No. 807,501, was filed April 19, 1905, a week subsequent to the date of the invention in suit which I have been instructed to assume.

SUMMARY OF THE PRIOR ART.

I. APPARATUS.

1. Campbell Morfit Extract from Treatise on Chemistry Applied to the Manufacture of Soap and Candles, of 1860.
2. Wagner, No. 373,113 of 1887.
3. Boulton, et al., and Gabbett, British No. 840 of 1889.
4. Gabbett, No. 444,345 of 1891.
5. Elmore No. 653,340 of 1900.
6. Elmore No. 692,643 of 1902.
7. Stoveken, No. 729,805 of 1903.
8. Wolf, No. 787,814 of 1905.

Charles F. Chandler.

II. PROCESSES FOR ORE TREATMENT WITHOUT OIL.

1. Bradford, No. 345,951 of 1886.
2. Hockley, No. 466,753 of 1892.
3. Rouse, No. 469,599 of 1892.
4. Hebron and Everson, No. 471,174 of 1892.
5. Hebron, No. 474,829 of 1892.
6. Delprat, No. 735,071 of 1903.
7. Delprat, No. 768,035 of 1904.
8. Potter No. 776,145 of 1904.

III. PROCESSES FOR ORE TREATMENT WITH OIL.

(a) Oil and Ore Mixed; Mixture Treated with Water.
Haynes, British No. 488 of 1860.

(a^1) Oil and Ore Mixed; Mixture Treated with Acidulated Water.

1. Everson, No. 348,157 of 1886.
2. Fryer Hill Publication of 1889.
3. Criley-Everson Publication of 1890.
4. Schwarz, No. 807,501 of 1905, Application filed April 19, 1905.
5. Schwarz, No. 807,503 of 1905, Application filed May 27, 1904.

(a^2) Ore and Water Mixed; Mixture Treated with Oil.
Robson, No. 575,669 of 1897.

(b) Pulp Treated with Oil; Concentrates Separated from Surface.

1. Elmore, No. 676,679 of 1901.
2. Elmore, No. 689,070 of 1901.
3. Glogner, No. 736,381 of 1903.
4. Good, No. 745,960 of 1903.
5. Kendall, No. 771,075 of 1904.

(c) Pulp Treated with Oil; Concentrates Separated from Bottom of Liquid.

1. Cattermole, No. 763,259 of 1904 (Classification).
2. Cattermole, No. 763, 260 of 1904 (Emulsion).
3. Cattermole, No. 777,273 of 1904 (Granulation).
4. Cattermole, Sulman & Pic~~k~~ard, No. 777,274 of 1904 (Soap and Granulation).

(d) Pulp Treated with Oil; Concentrates Floated by Introduction of Gases through Pipes, or Generation of Gases in the Mixture.

1. Froment, Italian Patent No. 63,723 of 1902.
2. Froment British Patent No. 12,778 of 1902.
3. Froment Description and Drawings of 1903.
4. Cattermole, Sulman & Picard, No. 788,247 of 1905 (Soap and Flotation), Application filed March 29, 1904.
5. Sulman & Picard, No. 793,808 of 1905 (Bubbles), Application filed October 5, 1903.
6. Kirby, No. 809,959 of 1906, Application filed December 14, 1903.
7. Kirby, No. 838,626 of 1906. Application filed December 17, 1903.

I. APPARATUS.

1. *Campbell Morfit Extract from Treatise on Chemistry Applied to the Manufacture of Soap and Candles, of 1860.* This publication discloses a twirling fan for agitating and aerating liquid soap, so that after it is hardened it will float upon water.

This twirling fan may perhaps be well adapted to aerate soap, but it is not well adapted to agitate a gritty ore pulp.

2. *Wagner, Patent No. 373,113, November 15, 1887.* This patent is for a churn designed to unite together the separate particles of butter fat in the cream so as to form a solid mass of butter distinct from the buttermilk. This patent suggests an advantage from aeration during churning, but the patentee is in error in his chemistry. Aeration is not desirable in churning cream to separate the butter. This churn is not well adapted for aerating gritty ore pulp.

3 & 4. *Boulton, et al., and Gabbett, British Patent No. 840 of 1889, and Gabbett United States Patent No. 444,345 of 1891.* The two patents are for the same invention. The U. S. patent refers to the British patent and the corresponding patents in Belgium and France. The invention was thus patented in the United States, Great Britain, Belgium and France.

The invention consists of a mixer for liquids or semi-liquids, in which a revolving cone is arranged in a vessel, which by reason of its shape or of the use of suitable baffles or other means, retards the rotation of the liquid.

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The revolving cone develops centrifugal force, which tends to throw the liquid toward the larger end of the cone, thus effecting a circulation in the liquid which resists the rotation of the cone, and secures a very effective agitation or mixing. This apparatus is, therefore, a "cone mixer," and is the only cone mixer I know of. This cone mixer is diagrammatically shown in the patent in suit, and also in the three Cattermole patents Nos. 763,259, 763,260 and 777,273. The Gabbett patents show the details of construction of the cone mixer.

These details of construction include stationary baffles for retarding the rotation of the liquid.

The baffle details are not shown in the four other patents, except that in Fig. 2 of the patent in suit there is an outlet pipe a^1 standing vertically in the cone mixer, which performs the function of and is, in fact, a baffle. The three Cattermole patents referred to and Fig. 1 of the patent in suit omit the baffle detail, but obviously it was not necessary to repeat the details already published and explained in the Gabbett patents.

In this connection, I note that, while the earlier advertising matter of the manufacturers of the Gabbett or cone mixer gives full detail drawings including the baffles, the later advertising matter omits the detail of the baffles. The advertisement in the Journal of the Society of Chemical Industry of November 30, 1897, was undoubtedly seen by me, as I have been a subscriber to this Journal for many years, ever since it was organized; in fact, at one time I was President of this Socie-

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ty. This Society is an international society, has had three American presidents, and the Journal has a wide international circulation.

This cone mixer is well adapted to thoroughly agitate and aerate an ore pulp, and is the apparatus disclosed in the patent in suit for effecting that part of the patented process.

5. *Elmore Patent No. 653,340 of 1900.* This patent, though put in evidence by defendant, was not explained by any of defendant's witnesses.

The general type of mixing device here disclosed has received some consideration in the testimony for complainants.

The apparatus of the patent was particularly designed to gently mix ore pulp and oil, so as to avoid aeration. The patentee says:

> "The ore and water and the oil, which are thus mingled without being broken up, so as to form a uniform mixture" (Spec. 653,340, page 1, lines 54-57).

The uniform mixture here referred to as something to be avoided, is an emulsion, such as would result from violent agitation, and which, with the large quantities of oil used in this apparatus, would defeat the object of the process in which the apparatus is to be used, to wit: the flotation of the valuable mineral of an ore by oil buoyancy.

The apparatus also includes a centrifugal separator

for recovering oil from the oil-floated concentrates. From this centrifugal (h, Fig. 2), the separated oil is drawn up through the pipe q to the cistern o, in which a partial vacuum is created so as to remove any air bubbles which may have become incorporated in the oil. Some slight aeration might result from the action of the centrifugal separator. The patentee says:

> "in order to clear the oil from air-bubbles, I prefer to draw the oil up to the cistern by creating a partial vacuum in the cistern" (Spec. 653,340, page 1, lines 88-91).

It is also suggested that instead of employing centrifugal force to separate the oil from the oil-floated concentrates, the oil may be separated by first heating it or thinning it with benzoline and allowing the concentrate to subside, or subjecting it to filter pressing. It is notable that the oil which is to be used is a very thick and viscous oil, compared to which oleic acid is a very thin oil. The oil is described as follows:

> "The thick oil which I employ is the thick tarry residue, usually called 'residuum,' of mineral oil after some of the more volatile constituents have been distilled off" (Spec. 653,340, page 1, lines 24-28).

This, therefore, is an apparatus for oiling a pulp with great quantities of oil so as to avoid aeration, for recovering so much of the oil as practicable from the concentrate, and for removing any bubbles of air which may possibly have become commingled with the oil.

Obviously the apparatus is entirely unsuitable for briskly agitating and aerating an ore pulp, such as is necessary for the purposes of the patent in suit

6. *Elmore Patent No. 692,643 of 1902.* This patent discloses another variety of mixing apparatus for use in the Elmore bulk oil process. This patent also was put in evidence by the defendant, but was not explained by defendant's witnesses.

The apparatus consists of a trough, through which extends a horizontal shaft carrying screw-propeller blades which act to mix the oil and pulp, and propel it toward the exit end of the apparatus. The description of the apparatus is very brief. The patentee says:

> "As the liquid mineral pulp and oil are caused by the blades c to travel along the trough a they become thoroughly mixed, and the mixture issues by an opening f into a subsidence-tank g" (Spec. 692,643, page 1, lines 25-29).

I also refer to the companion patent No. 689,070 for a description of the operation. Here the patentee says:

> "The liquid mineral pulp, oil, and acid are caused to travel along the mixer A and become thoroughly mixed" (Spec. 689,070, page 1, lines 82-85).

The apparatus also includes a centrifugal separator for recovering the oil.

This corresponding process patent No. 689,070 merely adds to the earlier process patent the use of acid.

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It clearly states the function of the oil to entrap and float the mineral. The apparatus is, therefore, designed to mix, not to aerate, and is well adapted to mix a great quantity of oil with an ore pulp, and distribute the oil in contact with the valuable mineral, so that the mineral will be entrapped and floated by the oil in the next, or subsidence vessel. For this purpose, the blades should be revolved at a comparatively slow speed. High speed would defeat the object of the apparatus. The apparatus is a good mixer when aeration is not desired, and when considerable quantities of oil are used. It would be an entirely inefficient device if an attempt were made to use it for the purposes of the patent in suit.

7. Stoveken Patent No. 729,805 of June 2, 1903. Here we have a mixing device for use in a cyaniding process. Aeration is here desirable to accelerate the chemical action, but not by any means for the purpose of producing a froth. Wings j or baffles are provided which the patentee says will roll back the pulp to the center of the tank. This the patentee says,

> "is materially advantageous, since in addition to being kept in suspension the material is worked up and down, and consequently the cyanide solution is caused to absorb the necessary oxygen and effect a rapid and complete dissolution of the gold and silver contained in the ore" (Spec. 729,805, page 3, lines 2-8).

It is very evident that this apparatus is not designed

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for the high speed that would be required if an attempt were made to use it for the purposes for which the agitating apparatus is used in carrying out the process of the patent in suit. Nevertheless, if it were materially strengthened, it would probably do very well. It might possibly be made use of, if more rigidly and strongly built, by a metallurgist to whom the invention of the patent in suit had been disclosed, as a modification of he agitating apparatus disclosed in the patent in suit.

8. *Wolf Patent No. 787,814 of April 18, 1905.* Although this patent was issued six days after the date of he invention of the patent in suit which you have asked ne to assume, I note that the application was filed May 2, 1903. The mixer B shown in the upper left hand orner of the drawings is described by Mr. Sulman as he well known Johnson mixer purchased from a London manufacturer of that name. The operation of this nixer is evidently very similar to that of the cone mixer nd I should be much inclined to characterize the apparatus as representing an effort to get the effect of the one mixer without infringing the Gabbett patent. Instead of the revolving cone, which moves the liquid up r down by centrifugal force, we have a stationary cylinder, and a turbine wheel B2 below the open end of this ylinder which operates to move the liquid up or down n the cylinder, thus effecting substantially the same circulation as in the cone mixer. Radial arms supporting ie inner cylinder act as baffles to retard the movement f the liquid.

This is evidently a very good mixing apparatus, and, if operated at sufficiently high speed, would aerate the liquid. It was clearly not so operated in the Wolf process. After the publication of the patent in suit, a metallurgist might well use this Johnson mixer as a modification of the mixing and agitating apparatus disclosed in the patent in suit.

This patent, although I have classified it in apparatus, discloses a process which has been referred to in the testimony as the Wolf or Scammel process. Mr. Chapman briefly describes it in answer to 134-XQ at page 207 of Complainants' Record. Mr. Ballantyne also refers to it and its total failure (Complainants' Record, pages 271, 272).

General Remarks on Apparatus. There are other documents which disclose apparatus, but it would not be worth while to discuss them under this heading. Some apparatus is necessary to carry out any process, whether the apparatus be the simple test tube of the laboratory, or more elaborate apparatus known to the chemist or metallurgist, or special apparatus designed for the particular process. Process and apparatus are usually distinct inventions. The patent in suit is for a process. To dwell too much upon apparatus would tend to confuse the issue.

P. 866, after L. 15, insert : The process is a modification of the Elmore oil flotation process, and does not in any manner resemble the process of the patent in suit. Aeration must be avoided in the mixing and separating. After the separation of the values from the gangue has been completed, the worthless residues are submitted to a treatment to recover the oil from them, this treatment consisting in blowing air through them to separate and float the oil.

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II. PROCESSES FOR ORE TREATMENT WITHOUT OIL.

1. *Bradford Patent No. 345,951, of July 20, 1886.* This patent has been sufficiently explained. It depends upon flotability by surface tension. It lacks any positive neans for differentiating the valuable mineral from the angue and is open to the serious objection that, in some nstances, it is as apt to recover gangue as it is to recover valuable mineral, and, therefore, the recoveries re not usually concentrates.

I note from Mr. Ballantyne's deposition (C. R., page 76) that the patentees of the patent in suit, Messrs. ulman, Picard and Ballot, without knowing of the radford patent, worked out a similar process and gave a thorough trial and abandoned it as worthless.

2. *Hockley Patent, No. 466,753 of January 5, 1892.* his patent does not disclose a process for concentrating res and has really no place in the present classification. he invention consists of an apparatus for sliming ores. s aim is to recover exceedingly finely divided metallic old or silver, bringing them to the surface of a body of ater by an up-current and retaining them there by rface tension. It is not remotely related to the invenon of the patent in suit, and if of any practical value, hich it does not appear to be, would never be used as auxiliary even to the process of the patent in suit, cause the process of the patent in suit is unique in at it concentrates and saves all slimes. No one ever

did this before in a process of ore concentration except Cattermole, and Cattermole's process, as appears in evidence, was immediately abandoned with hardly a practical trial when the invention of the patent in suit was made.

3. *Rouse Patent No. 469,599 of February 23, 1892.* This is another process for saving something from the slimes which are usually wasted. It is not a concentration process at all. It simply provides for carrying fine particles to the surface and floating them there by surace tension. It is no nearer to the invention of the patent in suit than Bradford or Hockley.

No oil is used, no agitation, no acid and the floating material is as apt to be gangue as valuable mineral.

It may be possible that a few bubbles, when they reach the surface, do not burst, but it is certainly true that most of them do when they reach the surface, and the others shortly thereafter.

4. *Hebron & Everson, Patent No. 471,174 of March 22, 1892.* This is the second patent of the Everson series, and marks the abandonment of the use of oil to assist in floating the mineral.

It is founded upon the notion that material can be pressed into cavities between the atoms of a molecule of metalliferous matter. This is absurd.

5. *Hebron Patent No. 474,829 of May 17, 1892.* This is stated to be an improvement upon the Hebron & Everson patent last considered, the improvement consisting in heating an ore so as to drive the air out of its alleged

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pores between the atoms of the molcules and forcing in buoyant material, by pressure, and then aerating the surface. After this has been done, the effort is made to float it.

This is the last patent of the Everson series. Carrie J. Everson was one of the patentees as the assignee of a part interest. It marks a sad ending of an enterprise which started with real genius.

Carrie J. Everson discovered the great assistance to ore separation by oil which was effected by the use of an acid, but she worked this out in an utterly impracticable bulk oil process. The cost of oil was prohibitive. Instead of discovering the possibility of the utilization of a minute quantity of oil, she abandoned oil, and the enterprise ended in these two ridiculous patents founded upon altogether untenable theories of molecular construction.

6 and 7. *Delprat Patents No. 735,071 of August 4, 1903, and No. 768,035 of August 23, 1904.*

8. *Potter Patent No. 766,145 of November 29, 1904.*

These three patents will all be considered together. They disclose processes for generating gases in an ore pulp by the action of acids, nitric or sulphuric. The gas utilized is probably carbonic acid gas, although Delprat, in his second patent, and Potter speak of sulphuretted hydrogen. The gas is supposed to select the metallic particles and float them to the surface, producing a tender float. This Dr. Byrnes illustrates in his illustrative Experiment 4, described on page 159 of Defendant's Record. No oil is used and there is no aeration by agitation.

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General Remarks on Processes not Using Oil. These proposed processes, in which no oil was used, are of interest as showing the activity of inventors during a period of twenty years from 1885 to 1905. In considering the processes which used oil, it will be found that the Everson patent, the application for which was filed August 29, 1885, and which uses a great amount of oil, and which is altogether out of question because it uses so much oil, was at the beginning of this period. The process of the patent in suit was invented, according to the date that I am to assume, on April 12, 1905. The eight patents above explained appeared successively at different times during this interval. They may all be taken as efforts to save the expense of oil. Two of them were further developments of Everson, but with the abandonment of oil. Not one of them discloses the process of the patent in suit and they do not lead to or suggest the process of the patent in suit. They are evidence of the desirability of the object which was attained by the process of the patent in suit, and they show that many other inventors worked with the same object, but utterly failed and missed the invention.

III. PROCESSES FOR ORE TREATMENT WITH OIL.

(a) Oil and Ore Mixed; Mixture Treated with Water. Haynes British Patent No. 488 of 1860. This patent discloses a process of ore separation in which powdered ore is mixed with an agent composed of substances not

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soluble in water, one class of these substances being fatty or oleaginous matters. It may be said generally that he describes the making of a mixture which would be a stiff paste and then triturating in water to wash out the gangue. A procedure is also described for removing the agent from the metal.

It should be noted that for sulphurets, for which the patent in suit is especially adapted, Haynes does not use any oily or fatty matter in conjunction with his bituminous combination of coal tar, resin, etc.; and further that his proportions of bituminous agent are very large, from one to five of ore (20 per cent.), to one to nine of ore (11 per cent.). The name "sulphurets" is the old name for sulphides.

Adjourned to Tuesday, December 10, 1912, at 10:30 in the forenoon, at the same place.

New York, December 10, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Direct-examination continued:

(Answer to 124-Q continued):

(a[1]) Oil and Ore Mixed; Mixture Treated with Acidulated Water.

1. *Everson Patent No. 348,157 of August 24, 1886.* This patent discloses two methods of treatment. The first is altogether impracticable and has not been commented upon by Dr. Byrnes.

A compound is made of sulphuric acid, cottonseed oil and water and mixed with the ore so as to produce a stiff mass or pudding. I have tried this with indifferent results.

The second method I have also tried. This Dr. Byrnes says he has tried, but the procedure which he adopted is not warranted by the Everson disclosures. His test as described on pages 163 and 164 of Defendant's Record resembles the Everson procedure only in the quantities of materials used. In all other particulars he uses the knowledge of today and by repeated agitation in the slide machine, without oil additions, and by removing his floating material as fast as it is formed, he reduces the amount of oil in each successive treatment and, as there were nine successive treatments, he probably had removed the greater part of his oil before the last treatment.

I carried out the instructions of the Everson patent as to the second method of treatment described therein in the following manner: I took 16 oz. of defendant's ore, crushed so as to pass through an 80 mesh sieve, and 24 drams of petroleum, and mixed the same thoroughly in a porcelain mortar. The result was a damp sand resembling molding sand. I then prepared some acidulated water by adding 8 drams of oil of vitriol to four gallons of water, the above being the proportions suggested in the Everson specification. I then put the ore, mixed with petroleum, in a slide machine with 1700 cc. of the acid water and agitated thoroughly for two minutes.

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On stopping the agitation an oily mess appeared on the top of the water in the machine.

I then ran the contents of the slide machine, while the agitation was continued, into a washing out vessel, in which there was an upward ~~under~~current of acidulated water with constant overflow. The result was concentrates 119 grams, tailings 255 grams. There was little difference between them. There seemed to be little more valuable mineral in the concentrates than there was in the tailings. Some of the material remained behind in the slide machine. The separation was a complete failure.

This Everson patent is of interest as containing the first disclosure of the use of an acid in connection with oil to prevent the oil from attaching itself to the gangue. This was an important step forward in the art, but the amount of oil used in the Everson patent was prohibitive. Apparently an attempt was made to use this process with silver and gold ores, but even with these ores the process appears to have been a failure, as it has only been heard of in connection with two published experiments, which I shall now consider.

2. *Fryer Hill Publication of 1889.* This article in the Daily Herald Democrat, of Leadville, Colorado, dated October 30, 1889, describes an effort to use a process resembling the Everson process on silver ores. Petroleum is the oil used and the water is acidulated with sulphuric acid. Steam is used to heat the mixture and in this respect the Everson process is improved upon. An upcurrent in the agitator causes the mineral-charged oil to

be carried to the surface, where it is trapped by closing two semi-circular doors beneath it, and then the mineral-laden oil is removed to settling barrels. The newspaper report is quite enthusiastic and says that there are thousands of tons of this ore awaiting this treatment. Apparently nothing more was heard of this effort to use the Everson process with silver ores.

3. *Criley-Everson Publication of 1890.* This article in the Engineering & Mining Journal of November 15, 1890, describes what appears to be a laboratory test of the Everson process with a gold ore of the Eureka & Excelsior Gold Mining Company. A black thick oil and acidulated water heated nearly to boiling are described as having been used. The description reads like that of an Elmore bulk oil flotation experiment.

This is the last that was heard of the Everson process as an oil ore concentration process. In the subsequent patents of the Everson series, no oil is used. These are the Hebron & Everson patent, No. 471,174 of 1892 and the Hebron patent issued to Carrie J. Everson as one of the assignees, No. 474,829 of 1892. I considered these two patents in their proper place and commented there upon the fact that they indicated that the great expense of the large quantities of oil used in the Everson process was overcome by abandoning altogether the use of oil.

4 and 5. *Schwarz Patents Nos. 807,501 and 807,503 of December 19, 1905.* The application for the first of these patents was filed April 19, 1905, and it is, therefore, too late to be considered as a prior document to the

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application for the British patent corresponding to the patent in suit, filed April 12, 1905. This document is, therefore, very nearly contemporaneous with the first official document disclosing the invention of the patent in suit. It discloses what is clearly a bulk oil flotation process and the injection of air or gas to give a certain sponginess to the mass of oil carrying the mineral so as to increase the floating power of this mass of oil and mineral.

The second Schwarz patent, No. 807,503, was issued on an application filed May 27, 1904, and is, therefore, to be considered as a prior document. This also is a bulk oil flotation process, in which the mineral is entrapped in and floated by the oil. Oil is used in sufficient quantities to make with the ore a thick pasty mass, which is first mixed without any water and then mixed with water.

> "The mass is then allowed to subside, when the selective material with the entrapped metallic constituente of the ore, will rise to the top and may be removed in any suitable manner, as by floating over the top of the vessel" (Spec. 807,503, page 1, lines 65-69).

The selective material is oil. During the first mixing, air or gas is blown in to give the thick pasty mass a certain amount of sponginess. After the admission of water the blowing of air, steam or gas may be continued.

Dr. Byrnes describes on pages 162 and 163 of De-

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fendant's Record an alleged Schwarz test, but as he only used sufficient oil to give the mixture of oil and ore the consistency of molding sand, which is a slightly damp sand, it is quite certain that he did not follow the directions of Schwarz and did not produce a thick pasty mass of such consistency that it would acquire sponginess when air was blown in it.

I carried out this Schwarz process in accordance with the directions of the patent in a test which I will now describe.

As Schwar~~t~~z states in the second patent that he prefers crude petroleum or any of its products, to which is added about 9 to 10 per cent. by weight of paraffin, I prepared the following mixture: 90 grams of crude petroleum, in which I dissolved 10 grams of paraffin wax. I then weighed out 300 grams of defendant's ore, crushed so as to pass through an 80 mesh sieve, and mixed it with the petroleum and paraffin. The whole formed a thick paste. This I put into the slide machine, pumped air in at the bottom, and kept the agitator going slowly. There was not enough material to keep the agitator covered. The material, was so thick that it piled up at the sides and corners, and the air, which was blown in underneath it through a perforated coil, made channels at one or more points and then blew through these channels without aerating the mixture. I, therefore, decided that a greater proportion of oil was necessary, and material enough to well cover the agitator, so I added 300

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grams additional ore and 200 grams of the mixture of paraffin and petroleum, the result being 600 grams of ore and 300 grams of the mixture of paraffin and petroleum, the latter amounting to 50 per cent. of the weight of the ore. I then continued the agitation and the injection of air.

I next injected water under pressure, continuing the agitation and adding 2cc. of sulphuric acid, and also continuing the injection of air. There was produced a floating mass on the top of the contents of the machine about one-half an inch thick, mainly oil, with some air bubbles and some mineral, but with considerable gangue. On examining the tailings I found them full of oil and of minerals. The process was a complete failure.

Schwarz got very little further than Elmore in oil economy. The process does not appear to be of any practical value whatever and is very far removed from the process of the patent in suit.

(a^2) Ore and water Mixed; Mixture Treated with Oil.

Robson Patent No. 575,669 of January 19, 1891. The process here disclosed is unique, in that the ore is brought into a moist condition by the admixture therewith of a small quantity of water, from 25 to 35 per cent., and an attempt is made to wash out the mineral with oil in a mixing vessel in which the "mud or mass" is to be brought into intimate contact with the oily liquid. The quantity of oil used in such a

process would, of course, be enormous and prohibitory.

(b) Pulp Treated with Oil; Concentrates Separated from surface.

1 and 2. *Elmore Patents No. 676,679 of June 18, 1901, and No. 689,070 of December 17, 1901.* The second of these patents differs from the first only in that acid is added to the ore pulp.

Both are bulk oil flotation processes in which a great quantity of oil is used, which acts to entrap the mineral and float it to the surface by reason of the fact that the specific gravity of the mixture of oil and mineral is less than that of water.

Brisk agitation must be avoided because it would tend to make a uniform mixture or emulsion, which would prevent the separation. An effort is made to save some of the oil by treatment in a centrifugal machine or by a filter press, and the recovered oil is treated to an air withdrawing operation, so as to remove any air bubbles that may possibly have gotten into the oil.

Dr. Byrnes very properly says (D. R., page 204) of the four Elmore patents, two for apparatus and two for processes, all of which I have considered, that they

> "relate to the flotation of mineral by oil *per se* rather than gas."

And also that

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"The flotation processes described therein do not rely on aeration or the evolution of a gas."

It is in evidence that these Elmore processes were tried in practice and long since abandoned, and this I can well understand, since the loss of oil, with all the efforts made to recover it, would be very much greater than the amount of oil used in the process of the patent in suit.

I have made several tests of the Elmore process. The amount of oil with Broken Hill ore required for carrying on the process would be about 6,000 pounds of oil for a short ton of ore. This is not all used at once, and a reasonable way of carrying out the process would be to use 100 per cent. of oil at a time as described by Mr. Chapman on page 205 of Complainants' Record.

I carried this out in practice and measured the thickness of the oil layer which constituted only 100 per cent. of the ore. This layer was one inch in thickness in a large test tube, and a trifle under one inch in thickness, in fact, 15/16ths of an inch, in a glass cylinder about three inches in diameter.

3. *Glogner Patent No. 736,381 of August 18, 1903.* This is the first of the graphite patents and describes a bulk oil flotation process for separating graphite from gangue. The oil used is petroleum and the quantity used is about half that of the graphite contained in the ore. The mixing vessels are suspended pots, "preferably operated by human force" at the rate of thirty shocks per minute, or one every two seconds. Dr.

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Byrnes theorized on this process, but apparently has not tried it in practice. He says that the agitation of these swinging vessels will intermingle with the pulp a large amount of air.

> "just as an ocean wave entangles air and forms a floating froth or foam" (D. R., page 130).

Again at Defendant's Record, page 170, he says:

> "Glogner 736,381 illustrates an oscillating, agitating vessel, in which the mixture of ore pulp and water is thrown violently against one end of the vessel, the wave falling back through the air, thus imitating aeration and frothing produced by an ocean wave."

I tried this out in practice. Not a particle of froth or foam was formed. The graphite floated to the surface entrapped in an oil layer, which was remarkably smooth. Instead, however, of using a swinging vessel, I used a bottle. Mr. A. Howard Higgins supplied the human force, and very vigorously shook the bottle at the rate of thirty sharp shocks per minute.

4. *Good Patent No. 745,960 of December 1, 1903.* This is really an apparatus patent for treating graphite in a bulk oil process. The apparatus and its operations have been fully described by Dr. Liebmann and I shall not repeat his description, as the patent discloses nothing having any relation whatever to the process of the patent in suit.

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5. *Kendall Patent No. 771,075 of September 27, 1904.* This is the third and last of the graphite patents. It describes a process for treating graphite or graphite waste with kerosene oil or "paraffin oil," as it is called in England,

> "which adheres to and by reason of its levity separates the graphit~~e~~ic substances" (Spec. 771,075, page 1, lines 14-16).

This is clearly a bulk oil process in which the mixture f oil and graphite must be light enough to float on he surface of the water. This is true of the three raphite processes which I have considered and they are o nearer to the process of the patent in suit than is the lmore bulk oil buoyancy process.

(c) Pulp Treated with Oil; Concentrates Separated om Bottom of Liquid.

1. *Cattermole Patent No. 763,259 of June, 21, 904.* This is the Cattermole classification process for parating granules of mixed sulphides obtained by the attermole process or breaking down the granules. This really a supplement to the Cattermole process, and not itself an ore concentrating process.

2. *Cattermole Patent No. 763,260 of June 21, 1904.* his is the emulsion patent, and is a division of the plication for the Cattermole granulation patent next be considered, and everything described in it is also scribed in that patent, which I will now consider.

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3. *Cattermole Patent No. 777,273 of December 13, 1904.* This is the granulation patent and constitutes the next real step forward in the art after the Elmore patents.

A great reduction is made in oil quantities from those used in the Elmore process. Instead of 6,000 lbs. of oil to the ton of ore, we have a recommended proportion of from four to six per cent. of the weight of the metalliferous mineral present in the ore, which, with Broken Hill crude ore, which contains about 50 per cent. of mineral, would be 2 to 3 per cent. on the ore. With Broken Hill tailings containing about 30 per cent. of mineral, this recommended percentage would be 1.2 to 1.8 per cent. on the tailings, which in this instance would be the ore.

It is very evident from this patent that the process is not adapted for use with lean ores since there is a caution to increase the amount of mineral if there is but little mineral present in the ore.

The fundamental idea of this patent is the production of agglomerated masses having sufficient falling power in water to enable the gangue to be carried upward away from the mineral by an up-current of water, the mineral falling to the bottom of the up-current vessel.

No amount of juggling with figures can make this a flotation process. Dr. Byrnes appears to have finally convinced himself that the process of this Cattermole patent

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"is one of oil-gas flotation" (Def. Rec., page 214).

This conclusion is so greatly at variance with the lisclosures of the Cattermole granulation patent that it eems incomprehensible that it could have been reached ven as a result of pure mathematics dissociated from ctual tests.

I have tested this Cattermole process and have obained results such as this patent describes. The process extremely interesting, and if the process of the patnt in suit had never been invented, it might have been seful to-day.

It is in evidence, however, that it was immediately isplaced by the process of the patent in suit after a ort trial, in which the oil consumption alarmed the ine owners, and efforts were made to reduce the oil onsumption (Chapman Deposition, C. R., page 174).

4. *Cattermole, Sulman & Picard Patent No. 777,-74, of December 13, 1904.* This is the first of the soalled soap patents, and is known as the Soap and ranulation patent. It discloses granulation according the Cattermole process with the use of soap, which is compound of oleic acid and soda, and which is deomposed into oleic acid and soluble sodium sulphate sulphuric acid. The process described is the granution process with this modification as to the oily marial and the method of obtaining it.

I note that Dr. Byrnes succeeded in convincing himself by mathematical computation that this patent was, like the Cattermole patent No. 777,273, one of oil-gas flotation (Def. Rec., page 214). I quote from the patent as follows:

> "This process may conveniently be rendered continuous by feeding ore-pulp, soap solution, and mineral acid continuously into one or more agitating vessels and discharging the products of agitation into an up-current separator, which allows the metalliferous granules to fall to the bottom of the vessel, while the particles of gangue are carried away by an upward stream" (Spec. 777,274, page 1, lines 66-74).

It is very evident that Dr. Byrnes had forgotten the language employed by the patentees when he reached his remarkable conclusion.

Adjourned to Wednesday, December 11, 1912, at 10:30 in the forenoon, at the same place.

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New York, December 11, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Direct-examination continued:

(Answer to 124-Q continued:)

(d) Pulp Treated with Oil; Concentrates Floated by ntroduction of Gases through Pipes, or Generation of Gases in the Mixture.

1. *Froment Italian Patent No. 63,723 of 1902.* The pecification of this patent is dated May 20, 1902. The pecification starts with a statement of four phenomna studied by the inventor which are stated to have erved as a basis of the process which forms the subect of the invention. The four phenomena are then riefly stated and are followed by a statement of a est tube example, in which proportions are given or ndicated and agitation for a period of a second is diected. This test tube example, when performed as irected, results in the flotation of a magma or paste f oil and mineral with gas bubbles in it. After the escription of the test tube test, the patentee says:

"Such is the principle."

Then follows as example 1, a description of an ore nd a statement that only a few seconds are necesary for completely separating the sulphide of one of

the metals from the rest of the gangue. This means, of course, the complete operation of agitation and subsidence. Then follows, as Example 2, a brief description of another ore and a statement that it had been treated in the same manner and with the same success.

It will be noted that we have here no description of any process except a process carried on in the simplest laboratory apparatus, to-wit: a test tube. That process appears to be workable in that apparatus. I have tried it and have obtained fair separation of the metals from the gangue. Possibly if I had the same ore Froment had, I might have come nearer to the complete separation which he describes.

I have said the proportions are either given or indicated. The weight of the ore, 10 grams, of the limestone, one gram, and the water 30 grams, are precisely stated. The amount of sulphuric acid is stated as a few drops. This is indefinite. Certainly the sulphuric acid has to be used with caution, as it effects a gas generation reaction, which, if too violent, will expel the contents of the test tube, but the caution of the specification is against excess of limestone, not excess of sulphuric acid, and one gram of limestone would require one gram of sulphuric acid, concentrated, for its complete decomposition. This would be about 26 drops from a bottle, or 32 drops from a pipette with a small opening, or 23 drops from a pipette with a large opening.

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The quantity of oil is specified as a thin layer. The kind of oil is specified as ordinary oil. The ordinary oil of the oil process of ore concentration known at that time, to-wit: the Elmore bulk oil buoyancy flotation process, was thick residuum oil. The layer in a test tube of this Elmore process, using the minimum quantity of oil for such tests, is at least an inch thick. It appears in the testimony of Mr. Ballantyne (Complts. Record, page 308) that this Elmore process was in use at the mines in Traversella, Italy, where Froment was engineer. Therefore, in my opinion, it is a reasonable interpretation of the meaning of the statement "a thin layer of ordinary oil," that a layer from an eighth of an inch to a quarter of an inch in thickness of thick residuum oil is described.

The thinnest possible layer of this thick residuum oil requires a quantity of oil 11.7 per cent. of the ore, 42 drops, equivalent to 1.3 cc., but Froment evidently did not mean to describe the thinnest possible layer, but only a layer which would be thin as comparable with the inch thick layer of Elmore.

The time of agitation is definitely stated. The mixture is to be agitated for a second, as the reaction generating the gas is an instantaneous reaction and the gas will escape if the agitation is continued for anything more than a brief space. This explicit direction to agitate for just one second is reasonable and what I would expect.

I have obtained a floating magma containing a fair

proportion of the mineral by agitation for one second and have then destroyed or greatly diminished the float by agitation for a few seconds more. Froment had but one idea, and that was to float the mineral by carbonic acid generated chemically, and he has disclosed in this patent a very interesting and fairly effective test tube operation, which, if carried out in accordance with his directions, is successful, but which, with a too long agitation, fails because of the escape of the generated and liberated gas.

As I said, the only procedure described in the patent is the test tube operation. It is rather surprising to read at the end of the specification that there are several distinct, but connected operations in the practical working of the process. The only working that has been described is a test tube operation, which is certainly not a practical working. These operations of a practical working process which have not been described are then set forth and I will enumerate them with exact quotations:

> (1) "The formation of the spherules and their separation from the gangue."
>
> (2) "Then separation of the concentrates and the oil and recovery of this latter for re-entrance into the circuit of operations."

The part which I have numbered (2) has not been heretofore described, but it was a well known step in the Elmore process and probably the inventor deemed it unnecessary to describe it. He says:

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> "The products of the concentration form oil cakes."

This indicates that the oil is recovered in a filter press, as suggested in the Elmore patent No. 676,679. As such procedure does not recover all the oil, his statement is quite accurate. His concentrate would be in the form of oil cakes, the particles of the concentrate adhering together by reason of the oil left in contact with them.

The claim gives a little further description of the oil. It is stated to be

> "an oily fat body,"

and it is stated not to be

> "an oily body derived from bitumens, tar, naptha, etc."

This excludes wood tar, coal tar and all their derivatives, such for example as pine oil, sweet pine oil and wood tar oil. It also excludes all essential oils, such as eucalyptus and turpentine, since they are not fatty oils. It excludes the lighter distillates of petroleum, naptha, etc., but thereby includes thick residuum oil. Whatever he had in his mind, he describes a thick oil and as petroleum residuum was then used in the art as the ordinary oil for concentrating ores, I think it is evident that he meant to describe this petroleum residuum.

2. *Froment British Patent No. 12,778 of 1902.* The date of the application, with the provisional specification, of this patent, is June 4, 1902, which is about two weeks later than the date of the Italian specification. The patent was applied for and issued to Henry Harris Lake, of the well known firm of Haseltine, Lake & Company, London, patent agents, as a communication from Froment. The provisional specification is almost an exact literal translation of the Italian specification, except for the absence of the claim, and provisional specifications do not contain claims. The slight changes are such as one would expect from a translator who is a British patent agent. The statement as to the period of agitation, which in the Italian specification is "a second," appears in the British specifications as "a brief space."

The statement of the Italian specification that the products of the concentration form oil cakes, becomes in the British specification that the products of concentration form cakes. Other slight verbal changes are unimportant.

The British complete specification, which appears to have been filed March 4, 1903, repeats the provisional specification except for the opening statement that the invention is now "particularly described and ascertained" and the reference to what is known as the oil process of ore concentration, of which this invention is stated to be a modification, and except also for the claim at the end of the British complete specification, which

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is quite different from the Italian claim and suggests a process in steps: (1) mixing the finely powdered ore with water; (2) adding a suitable oil; and (3) then liberating a gas in the mixture. There is no reference to squeezing out the oil from the concentrates in this claim and very properly, because this was old in what was then known as the oil process of ore concentration, to-wit: the Elmore bulk oil buoyancy flotation process.

The only definite disclosure of either of these patents is of a test tube operation. The remainder of the patents is theory and speculation. Each patent itself describes the only definite disclosure in it as an example of the principle, and the Froment patents are, in fact, patents for a principle, not worked out into any practical or useful process.

I have made a number of test tube tests according to the test tube operations described in the Froment patents, and departing from it in the use of other oils which were used by Dr. Byrnes in his tests alleged to have been according to Froment, but substantially different from Froment in every instance. Two of my tests are as follows:

Experiment 1. I took 10 grams of defendant's ore, crushed to pass through an 80 mesh sieve. To this I added one gram of pulverized calcite (carbonate of lime), 30 cc. of water. I agitated them sufficiently to moisten the ore and the calcite and mix them together.

I then put five drops of oil of vitriol into the tube and a layer of Winter dark oil, just sufficient to cover the surface of the water, which amounted to 1.3 cc. I then gave it five shakes, which occupied one second, and on allowing it to stand for a moment, a magma rose to the surface which measured a vertical inch in thickness. The tailings at the bottom of the tube were fairly clean. I then shook the test tube another second. The magma diminished and measured less than one-half an inch, and the tailings appeared darker from the subsidence of some of the metallic particles. I then shook it another second, and the magma diminished to one-fourth inch. I then shook it another second and the magma diminished still further and the tailings became quite dark. I then shook it another second, and the magma remained about the same, but was nearly all oil.

Experiment 2. I took the same ore that I used in Experiment 1, 10 grams, limestone 1 gram, water 30cc., agitated sufficiently to wet the ore and limestone, then added 1.6cc. of oleic acid comparatively pure, 5 drops of oil of vitriol, agitated for one second. The result was a good half inch of magma. I shook it five seconds more and nearly all the magma disappeared, the mineral matter going to the bottom. Nothing on the top but a few clean bubbles and a little mineral floating by surface tension.

The following experiments are Dr. Byrnes' slide machine tests translated back to the Froment test tube tests.

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Experiment 3. I took 10 grams defendant's ore, same as before, 30cc. of water, one drop cottonseed oil, and 7.4 cc. of 1/10 normal sulphuric acid, equivalent to 0.036 gram of sulphuric acid; shook for one second; result, no separation of mineral and no flotation. Shook the tube for 8 seconds longer; the result was a little collection of bubbles on top containing a slight amount of unseparated slimes. There was no separation of minerals from the gangue and the experiment was an absolute failure. This was a translation of Dr. Byrnes' first experiment, page 165 of Defendant's Record.

Experiment 4. Experiment repeated, substituting 0.4cc. of cottonseed oil for the one drop of cottonseed oil in the previous experiment; everything else the same. Shook for one second, practically no separation of mineral from gangue; some bubbles on top; no mineral, only a little unseparated ore. This is Dr. Byrnes' second experiment, page 165 of Defendant's Record, translated from the slide machine to the test tube.

Experiment 5. This was the same as Experiment 4, with the substitution of 0.4cc. of olive oil for the cottonseed oil of the previous experiment. Shook one second, no mineral separation, few bubbles on top with a little unseparated ore.

Experiment 6. Experiment as before, except 0.4cc. of defendant's red oil was used, previously warmed slightly to make it thin ,as the room was cold; shook

for one second; no mineral separation; few bubbles on top quite clean, and very little unseparated ore.

Experiment 7. Same as before, with the substitution of Hegeman's comparatively pure oleic acid, 0.2cc., half as much as before. Result the same as in the other experiment.

I might note that the quantity of oil employed in all these experiments was only a fraction of "a layer" as called for in the Froment patents, and, further, that no limestone was added in these experiments, because Dr. Byrnes used none and, consequently, there was practically no carbonic acid gas produced, as the small amount of rhodochrosite in the ore would not be acted upon by the very dilute sulphuric acid present and could not furnish any material quantity of carbonic acid gas.

I then repeated these experiments employing the same ore which I previously de-slimed by means of water, washing out the slime by successive stirrings with water. I took 100 grams of the ore for this purpose; after washing out the slime, I dried the residuum of de-slimed ore and it weighed 64 grams, thus representing 64% of the original ore.

Experiment 8. De-slimed ore, a repetition of my Experiment 3. A small quantity of mineral came to the surface around the edge, not enough to form a layer, and this dropped quickly to the bottom; shook for only one second.

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Experiment 9. This is a repetition of my Experiment 4 with the de-slimed ore; shook one second; some floating material, heavy, and tended to drop back. Shook another second; a little larger amount of float. Experiment not a success, as there was no substantial separation of mineral from gangue.

Experiment 10. was a repetition of my Experiment 5 with the de-slimed ore. The result was the same as in Experiment 9.

Experiment 11. This is a repetition of my Experiment 6, with the de-slimed ore; shook one second; layer of bubbles; practically no mineral; bubbles quickly burst; most of the mineral dropped.

Experiment 12. A repetition of my Experiment 7, on de-slimed ore, using 0.2cc. of Hegeman's comparatively pure oleic acid; shook one second; very little float; particles sink and rise.

Not one of these experiments from 3 to 12 was a success.

I then repeated the same experiments, using Defendant's Feed to Flotation Plant, used by Dr. Byrnes, which had been exposed to air and dampness since the taking of Dr. Byrnes' testimony, and had suffered oxidation to a greater or less extent.

Experiment 13 was a repetition of Experiment 8. The result was very little float, which settled at once to the bottom.

Experiment 14 was repetition of Experiment 9. There was quite a layer. The particles, however, were heavy and tended to go down; not a good separation.

Experiment 15 was a repetition of Experiment 10. The results were substantially identical with those of Experiment 14; not a good separation.

Experiment 16 was a repetition of Experiment 11. There was very little float, which settled at once to the bottom; not a good separation.

Experiment 17 was a repetition of Experiment 12. There was quite a layer; the particles were heavy and tended to go down; not a good separation.

3. *Froment Description and Drawings of 1903.* Here we have for the first time a description by Froment of a process and apparatus capable of dealing with ore in practical quantities. He first directs crushing the ore so as to arrive at a distintegration of the particles without rendering it impalpable. The sieves are not described according to any standard known to me, or which I could ascertain. A wet process is recommended, as is undoubtedly best in practical operations at a mine or mill, and de-sliming is directed. He truthfully says that the fine slime eliminated by de-sliming could not be treated by any hitherto known method.

The de-slimed ore is fed into the mixing apparatus, which he calls a centrifugal mixing apparatus contain-

ing two stirring devices worked in opposite directions and making about 300 revolutions per minute.

Then the mixer is charged with ore and water, about 1% of carbonate of lime, maximum 2% in difficult cases, and about 1 to 1½ per cent. of mineral engine oil are added. The mixing apparatus is then allowed to work for ten minutes, the chief point being that all the sulphide grains shall come into thorough contact with the oil.

This is a clear statement of the necessity of thoroughly mixing the oil and the ore.

I have repeated this operation in "Complainants' Exhibit, Reproduction of Froment Mixer," with a richer ore, and therefore with more limestone and oil, and have mixed the ore, limestone and oil, and did not obtain a particle of mineral froth or any appreciable mineral float, and have also repeated it in a cone mixer, and have even repeated it in the slide machine. The result was always the same. The substances were mixed together and the oiled ore went to the bottom. This operation is, therefore, purely a mixing operation.

The process as thus described is for a lean ore. If the ore contained more than 5% of metallic matter, Froment says it would be necessary to use more oil, and recommends 2% for ore containing up to 15% of metal, indicating this as the upper limit for copper ores in the Latin countries, while for lead ores, which are richer, Froment recommends 2½% of oil for an ore containing 30% of metal, 3% of oil for 40% of metal, and 3½% of

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oil for 50% of metal. He says it seems reasonable to assume that the proportion of carbonate of lime will follow practically the same rule. This is, however, evidently a mere assumption. After the ore, oil and limestone have been mixed, the mixture is discharged into Froment's second apparatus, described as a vat with a coil, having a rake-like stirring device, to be operated at 10 to 12 revolutions per minute. Here sulphuric acid is added through a perforated coiled pipe at the bottom, and produces the chemical reaction which is the characteristic feature of the Froment invention. The greased sulphides are said to rise to the surface carried by gas bubbles. The rake, although moving slowly, disturbs this surface and it would be reasonable to expect that much of the mineral would sink again and that the gas bubbles would escape, leaving some mineral floating by surface tension. As a matter of fact, I tried this apparatus, "Complainants' Exhibit, Reproduction of Froment Vat with Coil" and it proved to be a very poor stirring device, merely forming grooves in the oiled ore at the bottom of the vessel, and I got hardly any float.

Froment says that the stirring rake is to prevent the ore from collecting at the bottom of the vessel in too compact a mass. If the stirrer were more efficient, it would do this. He admits that a small proportion of the greased sulphide which had been carried to the surface by the gas bubbles would fall back and get mixed with the gangue, and he provides for screening

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he residues from the bottom of this vessel. This part f the apparatus does not appear to be of any importance nd I shall not describe it.

The closing statement is that the concentrated ore ay be treated in a hydraulic press or filter press to ecover a very large proportion of the oil.

The test of "Complainants' Exhibit, Reproduction of roment Mixer" and "Complainants' Exhibit, Reproduction of Froment Vat with Coil" in accordance with roment's instructions, was made in the presence of r. Adolf Liebmann and myself, as well as two following tests, one with the cone mixer as the mixing apparatus and an efficient hand stirring in a shallow ssel, and the other with a modern slide machine as a ixing apparatus and the same efficient stirring. These sts are fully described by Dr. Liebmann on pages 0-523 of Complainants' Record, and I will not, therere, repeat this description. The hand stirring was th a glass rod and was carefully done so as to but ghtly disturb the surface of the liquid, and the oily neral float obtained was, therefore, not broken up it would have been by the revolving rake in the Froent vat with the coil. Therefore, the float obtained the hand stirring retained its gas bubbles to a conerable extent and was a somewhat pasty mass of oil d mineral with gas bubbles in it. I should say that h the Froment apparatus we obtained a very small ount of surface tension flotation, while in the other experiments the floating mass was very much like magma of the Froment test tube test.

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The Froment description and drawings describe a process and apparatus and show an apparatus which discloses a development of the undeveloped ideas of the Froment patents. They provide for effective oiling of the ore with a quantity of oil much smaller than is necessary in the agitation for one second exactly directed in the Italian patent, and substantially directed in the British patent, but the Froment patents and Froment's later disclosures in his directions and drawings fail utterly from the standpoint of practicability. The minerals consumed, oil, limestone and sulphuric acid, the latter two in such quantities as to generate the gas necessary for the flotation of the ore, cause a total cost which is prohibitive, even if the process could have been compelled to work successfully in practice. The cost of the oil alone is prohibitive. For Broken Hill ores, the oil consumption would be 2½% or 50 lbs. to the short ton.

I cannot seriously consider these Froment disclosures as a disclosure of the process of the patent in suit. The process or processes are so substantially different in all essential particulars that they are not comparable.

4. *Cattermole, Sulman & Picard, No. 788,247, Patented April 25, 1905, Application Filed March 29, 1904.* This is the second of the Soap patents, and is known as the Soap and Flotation patent. It is a companion patent to No. 777,274, the Soap and Granulation patent. It discloses the use of the soap reaction in the separation

of minerals in connection with practically all processes then known in which it appears to be utiliz~~ed~~able, except in the Granulation process covered in the companion patent patent No. 777,274.

It describes the removal of the coated mineral parti-cles from the gangue by generating gaseous bubbles in the mixture, or by the use of buoyant material, such as greased wood and sawdust.

It is a broad patent for the soap reaction in the con-centration of ores, and also specifically for the use of this soap reaction in the flotation processes as then known employing a smaller amount of oil than was nec-essary to float the mineral by buoyancy. It does not disclose the process of the patent in suit or anything like it.

5. *Sulman & Picard Patent No. 793,808, Patented July 4, 1905, Application Filed October 5, 1903.* This is known as the Bubbles patent, although the name is not descriptive, since the patent describes processes in which bubbles are not utilized, as well as those attempt-ing to use gas or air bubbles.

In the apparatus shown in Figure 1, the effort is made to utilize air bubbles to float oiled minerals to the surface in a body of liquid which is maintained in a turbulent condition by a coiled pipe rotating at the bottom of the vessel and discharging a jet of oil and water into the liquid.

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In the apparatus shown in Figure 2, oiled mineral is blown upon the quiet surface of the liquid in a series of spitzkasten. In the apparatus shown in Figure 3, the oiled mineral is fed down upon a rotating disc or table and is thrown outward by centrifugal force over the quiet surface of the liquid in a series of ring-shaped spitzkasten. Here no air is employed at all.

The result of all these processes is skin flotation or flotation of an oiled mineral by surface tension. That this is so as to the apparatus shown in Figures 2 and 3 is so apparent that no demonstration is necessary. As to the apparatus shown in Figure 1, I have tested it and have found that it is a poor device for oiling a mineral, but that it will to some extent float an oiled mineral by surface tension.

I used in my tests the apparatus put in evidence by the defendant as "Defendant's Exhibit, Apparatus of Patent 79,808." I only added to it for my first test the inclined baffle shown near the left hand end of the apparatus in Figure 1, which performs the function of causing all of the material to be submerged so that it will have a chance to become oiled. Without this the slime, mineral and gangue, would float off unoiled. I tried it at first with the oil-injecting apparatus supplied as part of the exhibit by defendant. This oil feed device, however, was so constructed that, when the air pressure was applied, the air bubbled up through the oil cup and prevented the oil from feeding down into the air pipe. I cannot understand how defendant's ex-

pert, Dr. Byrnes, used this device for injecting oil with the air. The moment the air pressure is turned on, the oil feed stops, and if the air is turned on first and then the exit of the oil cup is opened, the air pressure prevents all flow of oil. I, therefore, replaced this oil feed device, which would not feed oil, by an oil feeding device which I now produce, so constructed that the air pressure flowed freely into the oil cup above the oil. With this device and a thin and quite pure oleic acid obtained from Hegeman's Drug Store, I was able to feed the oil very effectively and thus carry out the inventors' idea of spraying the oil into the air on its way to the coil.

The following are the details of the experiment, with the coil apparatus of this patent. The ore used was defendant's ore crushed to 80 mesh, and 3,000 grams of ore were used, fed in at the rate of 500 grams per minute. The worm was rotated at a speed of 500 revolutions per minute. The air pressure applied was 5 lbs. to the square inch, running from a tank in which it was stored and controlled by a reducing valve. The total oil consumption was 30.5 grams. We put in 15cc. of 50% sulphuric acid at the commencement of the operation, and no further acid was added. The result was a few oily drops floated on the surface, one-sixteenth of an inch in diameter or less; no mineral on surface except a small surface tension float. Upon examining the pulp at the bottom of the trough, it was found to be not materially oiled. On standing, a little more oil came to the surface.

I could not verify Dr. Byrnes' statement as to this apparatus in any particular. He says, on page 141 of Defendant's Record, that the apparatus is well adapted to oil the mineral and float it as a froth. I found that it was very poorly adapted to oil the mineral and that it did not produce any froth at all. He says that the coiled perforated pipe acts as an efficient agitator to intermingle a considerable amount of air in the pulp. I found that it simply blew air through the pulp. He says, on page 165 of Defendant's Record, that he obtained a thick and satisfactory froth, of which he skimmed off many handfuls. I did not obtain any froth at all.

The disclosure of the ~~British~~ Bubbles patent well indicates the groping of Messrs. Sulman and Picard for a practical process of ore separation by flotation. If they had stopped with the ideas disclosed in this patent, they would not have advanced the art in any respect toward the goal which they ultimately attained, with the co-operation of Mr. Ballot.

The process of the patent in suit is not disclosed in this patent and Messrs. Sulman and Picard might well have been discouraged by the inefficiency and practical uselessness of all that is disclosed in this patent from any further effort to concentrate an ore by flotation assisted by air or gas.

Adjourned to Thursday, December 12, 1912, at 10.30 in the forenoon, at the same place.

Charles F. Chandler.

New York, December 12, 1912.

Met pursuant to adjournment.

Present: Counsel as before

Direct-examination continued:

(Answer to 124-Q continued:)

6 and 7. *Kirby Patents, No. 809,959 of January 16, 1906, Application filed December 14, 1903, and No. 838,626, Patented December 18, 1906, Application filed December 17, 1903.* The first of these two documents discloses a process of separating minerals. The second discloses a separating tank used in this process. In the process, a thin oil is used in the proportion of from 25 to 75 per cent. of the ore, which is from 500 to 1,500 lbs. to the short ton of ore. The oil is kerosene, having dissolved in it 5% of Trinidad asphalt.

The process is a buoyancy process, like Elmore, but the patentee hopes to assist the buoyancy of some of the particles by air. The patentee says (p. 2, lines 56-66):

> "Some of the hydrocarbon-coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant, and some of such particles and some globules of the mixture would be trapped in the sands. In order to recover this less buoyant material together with the globules of the mixture, the mass which tends to settle is

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> slowly lifted and turned over to liberate the coated particles and the globules, and at the same time a gas, preferably air, is blown into the mass, preferably near the bottom thereof."

That a floating layer of oil carrying mineral is obtained is quite clear. The patentee says (p. 3, lines 55-57):

> "The floating concentrates are carried mainly at the lower surface of the hydrocarbon layer, where it is in contact with the water."

Kirby mixes in one vessel, the mixer A, and then flows the mixture into another vessel, the separating tank B, in which this slow stirring and blowing in of air takes place and the floating layer of oil carrying mineral is formed. A skimming bar 28 carries the float into a settling and washing chamber or box 29 (Fig. 2) at the top of the separating tank, from which the flood flows into a filter which recovers part of the oil. The remainder of the oil recoverable is distilled from the concentrate in a retort.

This process is so plainly an oil buoyancy process that it seems surprising that Dr. Byrnes should mislead himself into the belief that it is a frothing process.

There is absolutely no foundation for this belief. Dr. Byrnes says (Defts. Rec., p. 151) that the mineral "floats as a froth" in a separating tank, and that the "froth of concentrates" is directed by the curved

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skimming bar into the settling and washing chamber. This directly contradicts the statement of the patentee above quoted that he has here a "hydrocarbon layer" (oil layer) in which "the floating concentrates are carried mainly at the lower surface * * * where it (the oil layer) is in contact with the water."

As for Dr. Byrne's alleged Kirby tests described on pages 161, 162, of Def. Rec., it is as different from Kirby as is Dr. Byrne's description.

The Kirby process is not the process of the patent in suit. It is an attempt to use the Elmore buoyancy process with thin oil and some economy in oil. I have tested it on a small scale and found that the thin oil did not very effectively hold up the metal in the floating oil layer, and that the streams of air only disturbed and sank the metal carried in the floating oil layer. The Kirby process is very far removed from the process of the patent in suit.

General Remarks on Processes of Ore Teratment with Oil. There are, in the six sub-divisions of this class of process, twenty-three documents. As the Froment Italian and British patents are identical in substance, we have twenty-two inventions each aiming to solve the problem of the economical and effective concentration of ores by the utilization of the preference of oil for the mineral. These inventions commence with Hayes in 1860. Then there is a gap of more than twenty-five years. Then comes Everson in 1886, the efforts to utilize it in modified forms in 1889 and

1890, Robson in 1897, the Elmores in 1901, Froment in 1902, the Cattermole series commencing in 1903 (application for patent No. 777,273), the graphite group, Glogner, Good and Kendall, in 1903 and 1904, the Kirby applications in 1903, the first Schwarz application in 1904, the Sulman and Picard first efforts in 1904. The Wolf process in 1904 I have considered under the heading "Apparatus." That may also be added to the list. This record of invention is a record of partial or complete failures. It is in evidence that Elmore was used to some extent and that Cattermole was used to a small extent, but both of these processes long ago disappeared from use. The amount of capital invested and lost in these unsuccessful inventions would, no doubt, make a stupendous figure. The human effort must have been very great.

But the process of the patent in suit solves the problem. It is simple, it is economical, and it is efficient. It can be used in simple apparatus. The expense of operation is slight and the recoveries are large, yet none of these prior documents discloses it. The phenomenon of the agitation mineral froth was an unknown phenomenon until discovered by Messrs. Sulman, Picard and Ballot, and made known by them in the patent in suit, and in twenty-four corresponding patents taken out in Europe, Asia, Africa, Australia and the Americas.

125-Q. Having now considered the prior art, both as set forth by the defendant and as supplemented in

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complainants' rebuttal testimony, what have you to say as to the novelty of the invention disclosed in the patent in suit?

A. The process of the patent in suit is a new process, not disclosed in any or all of the documents referred to by complainants or defendant as prior documents. It was to me a most surprising process. After studying all these prior documents, my surprise is not diminished that such a process is possible. There is nothing like it disclosed in the prior art and the failures of other inventors tended to discourage rather than to encourage the hope that the economical concentration of ores was capable of realization in a process utilizing the affinity of oil for metallic substances.

Of all the prior processes, the nearest approach to the process of the patent in suit was the Cattermole granulation process. Here there was agitation of an ore pulp with an amount of oil as small as 1½% of the ore, or 30 lbs. to the short ton, and with reasonably small quantities of acid, utilized only for its physical action in increasing the preference of the oil for the mineral. This was a simple and workable process, but it was the reverse of the flotation process. The agitation and oiling of the mineral caused the mineral particles to stick together and form granules having greater weight in proportion to their surfaces than the original particles, so that they not only went to the bottom, but they resisted an up-current of water strong enough to carry away the gangue. This taught that

the best way to concentrate an ore was to sink the metallic particles.

Then we have the Froment principle of generating carbonic acid by the use of sulphuric acid and limestone and attempting to float the mineral by the generated gas. Nothing of practical value came from this principle, and there was the Sulman and Picard idea of lifting the mineral to the surface by streams of air, and nothing of practical value came from this. Then we have the oil buoyancy processes of the Schwarz and Kirby—efforts to assist buoyant action of the oil by blowing in air—and, finally, we have the Elmore oil buoyancy flotation process, in which the mineral was made so light by entrapping it in great quantities of oil that the mixture of oil and mineral became lighter than water and floated. This briefly summarizes the prior art.

The simplicity of the process of the patent in suit is as remarkable as its economy. For continuous operation only two pieces of apparatus are required, an agitator for briskly agitating the ore pulp and beating air into it, and a spitzkasten or separator in which the froth may rise to the surface and float off into a launder. The oil consumption is one one-thousandth part of the weight of the ore treated, equal to 0.1%, equal to 2 lbs. to the short ton of ore. The acid consumption, since no chemical action is required or desired, is extremely small. Some heating is usually required, but this is not carried to such a point, as to be a serious item of expense.

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The remarkable thing about the froth produced in this process is its permanency. The bubbles of air, with water films, are thickly coated with mineral particles and appear to be armored by these metallic particles. The froth piles up thickly and carries the great weight of the mineral particles, which are the heaviest particles of the ore. The oil has entirely disappeared from sight and sense. It cannot be seen and it cannot be felt, and the particles of mineral are just as bright as though there was no oil upon them at all.

I regard the process of the patent in suit as one of the most remarkable and surprising processes which has ever been brought to my attention, and the invention is one of the most important inventions in the metallurgical art, and I further regard it as an entirely novel process not disclosed in the prior art.

126-Q. In considering the Froment Italian patent, you said that the thinnest possible layer of thick residuum oil required a quantity of oil 11.7% of the ore. What particular oil did you use in this test, and what capacity of test tube?

A. It was what is known as Winter dark oil; sample just received from London. I believe it is about the thinnest residuum oil that is known in the art of ore treatment. The Summer dark oil is darker and a thicker oil than the Winter dark oil, and I tested this and found that it required 1.4 grams of oil to make a layer of water in an 80cc. test tube, equal to 14.4% of oil on the ore.

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127-Q. Dr. Liebmann, in answer to 41-Q (Complts. Rec., page 524) says that you were present on November 5, 1912, when he repeated his test tube reproduction of Dr. Byrnes' alleged Froment slide machine tests. What have you to say to this?

A. This statement is true. I made careful notes of all these tests and can repeat them if desired. The tests which I have particularly described in my testimony were made later.

128-Q. It is suggested in the deposition of the defendant that the word "powdered," as used in the patent in suit, means dry, as applied to powdered ore. What have you to say as to this suggestion?

A. It is not limited to dry pulverization. When a substance is not soluble in water, it is quite common to grand it under water to an impalpable powder or pulp, which may or may not be afterwards dried. This is a very common custom with minerals, and has long been employed both for ores and for quartz, feldspar, etc., as used in the porcelain industry.

129-Q. What are the physical qualities of sulphuretted hydrogen, or hydrogen sulphide, and is it or is it not poisonous?

A. Sulphuretted hydrogen is a gas having a very characteristic and disagreeable odor. It is very offensive and poisonous, and I have heard of workmen being killed by it in factories where it was liberated; in fact, one of my assistants working in my laboratory was rendered insensible by it. Fortunately I was present,

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and with the assistance of two of my students I carried him at once into the open air and he recovered. As sulphuretted hydrogen is a very valuable reagent in chemical analysis, it is often employed in laboratories and its odor can often be perceived, but it is customary to have specially constructed hoods, well ventilated, in which the apparatus is placed while the gas is being utilized.

130-Q. Have you made a test of "Defendant's Exhibit, Apparatus of Patent in Suit," without using baffles in the cone mixer? If so, please describe it.

A. I have. The boxes or spitzkasten were filled with circuit water at a temperature of 50° Centigrade. The ore employed was defendant's crushed to pass through an 80 mesh sieve. 500 grams of ore and 3,200cc. of water, and 3cc. of oil of vitriol were put into the agitator. This quantity of acid was employed on account of the large amount of water in the agitator and the spitzkasten. The oil employed was defendant's red oil. The quantity employed was 0.75cc., which is equivalent to 0.675 gram, which would be 2.70 lbs. per ton of ore, equal to 0.13% on the ore. The ore, etc., was agitated for about two minutes by hand, with frequent reversals of direction. There were no baffles in the agitator. There appeared half an inch of froth in the agitator, and when the contents of the agitator were discharged, the froth ran out on the launder and floated on the spitzkasten. Considerable froth was left in the agitator. I should add that, before this ex-

periment was made, a gate-valve was substituted for the globe valve which was .on the original exhibit This facilitated the discharge of the froth. The apparatus of the patent was intended for continuous use, and such a test as this is not a fair test of the apparatus, and, as it was worked by hand, it did not give sufficient agitation. But, nevertheless, there was a considerable amount of froth in evidence.

Drect-examination closed.

Cross-examination by Mr. Scott:

131-XQ. Will you state what wood tar is and how it is prepared?

A. A wood tar is a product of the destructive distillation of wood. When wood is placed in a closed vessel and subjected to heat, the first product is water. When the temperature reaches something like 500° Fahrenheit, the woody tissue begins to undergo decomposition, and it gives off a variety of products which vary according to the particular kind of wood under treatment. If the wood is that of a deciduous tree, such as beechwood, acetic acid and methyl alcohol are among the first products next to water, the mixture being known in commerce as pyroligneous acid. If the heat is continued, tarry products come over, which condense into wood tar, and charcoal is finally left behind as the last product.

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If, on the other hand, the wood is a resinous wood, like pine or spruce, the first product will be water, then will come oil of turpentine, and then will come a series of oils containing quite a variety of chemical products, alcohols and ketones, which are known in commerce as pine oils, and, finally, pine tar, leaving charcoal behind.

If the tars thus produced are subsequently redistilled, oily products are obtained known as tar oils.

In the case of the deciduous trees, creosote is one of the oily products of the distillation. This is a mixture of phenol, cresol and the corresponding ethers.

I could go further, but probably I have given you all the information you want. I might add that tar, in general, no matter from what material it is produced, is a most complicated mixture of products.

132-XQ. Upon your direct-examination you referred to "wood tar, coal tar and all their derivatives, such for example as pine oil, sweet pine oil and wood tar oil." I take it from your last preceding answer that you did not intend, in the passage quoted, to convey the idea that pine oil and sweet pine oil are derived from wood tar. Am I correct?

A. The pine oil and the sweet pine oil would be in the tar if the distiller did not collect them separately. They belong primarily to the tar, which results from the destructive distillation of the wood, but in recent years, since a market has been found for pine oil, the distiller collects separately the first portion of the distillate and this constitutes pine oil. He has often re-

cently extracted pine oil by distilling the wood in a bath of melted resin, and thus obtained it in a purer condition than he could do if he first produced wood tar and then separated the pine oil from it. I think it is proper to call pine oil a derivative of wood tar, just as we call phenol and cresol derivatives of coal tar.

133-XQ. In the manufacture of pine oil and sweet pine oil, does the distiller first remove from the wood by distillation the various products you have mentioned, including pine oil and sweet pine oil, leaving the remainder as tar; or does the distiller first remove certain of the products, leaving a mass which he calls tar containing sweet pine oil and pine oil, and subsequently treat this residue or tar for the purpose of extracting the pine oil and sweet pine oil therefrom?

A. This business is carried on in three different ways. First, the old fashioned way, in which pyroligneous acid and tar are the only products, the pyroligneous acid containing the methyl alcohol, and the tar containing everything else. Subsequently the tar was exposed to fractional distillation and oils were obtained from it.

Second, pine wood is sometimes distilled by immersing it in small pieces in a bath of melted resin. In this way, a distillate is obtained which contains the lighter oils, which were formerly included in the tar by themselves.

Third, another plan which is practised by some of the distillers is to immerse the wood in a bath of very

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heavy petroleum oil and heat it at carefully regulated temperatures, so as to secure the lighter products containing the oils separately from the tar, which either comes over later or which they may not take the trouble to produce at all.

134-XQ. You have said that the process of Cattermole Patent No. 777,273 is not adapted for use with lean ores. Is there any reason why the process of the Cattermole, Sulman and Picard patent, No. 788,247, is not applicable to lean ores as well as to rich ores, that is, to ores containing a small amount of metalliferous mineral, as well as to those containing a large amount?

A. I don't know.

135-XQ. You do not find anything, do you, in the specification of patent No. 788,247 to indicate that the patentees thought their process inapplicable to lean or poor ores?

A. I find nothing in the specification which states in so many words whether the process is suitable for lean ores or not. The author mentions two or three ways of getting the particles of valuable mineral, after they are coated with fatty acids, to the surface, but he does not intimate whether one method is adapted for rich ores and another method for poor ores. I notice one of his methods introduces wood, sawdust or other suitable material which are to be made to adhere to the mineral particles to cause them to float, but he does not state whether this particular treatment is or is not adapted to poor ores.

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136-XQ. Referring to patent No. 788,247, what is your interpretation of the function performed by the oil which is used, that is, the oil which results from the decomposition of the soap?

A. I understand that it coats the particles of minerals with an oily film, which repels water, while the particles of gangue, being wetted with water, do not receive a coating of oily matter from the soap. The consequence is, if these particles of oiled mineral get to the surface, they float there by surface tension.

137-XQ. You stated in the first deposition which you gave in this suit, that, in the processes of Cattermole patents, 777,273 and 777,274, "so large an amount of oily matter is employed as to agglomerate together the metalliferous particles contained in the ore into granules or pellets." Is it your understanding that the amount of oil used in Cattermole, Sulman and Picard patent No. 788,247 is also of such a quantity as to cause the metalliferous particles to agglomerate together?

A. There is no statement in the specification of the quantity of soap added or the quantity of fatty acid to liberate it nor is there any suggetsion of agitation by which oiled particles of ore might be agglomerated into granules. After the oiling of the particles has been accomplished, the patentees merely suggest that these oiled particles may be brought to the surface by gas bubbles or brought to the surface by added particles of wood or saw-dust previously coated with fatty acids by means of the soap treatment.

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138-XQ. Do you find the specification of Cattermole, Sulman and Picard patent No. 788,247, to contain sufficiently explicit directions to enable one to apply the process there set forth and particularly that species of the process which includes, after oiling, flotation by gas bubbles?

A. The specification is certainly not very explicit. In the first place, it mentions a variety of substances to be added to the water, as soaps or similar compounds, such as cresols, phenols, resinous bodies, etc., and gives no idea of the preferable material and no idea of the proper quantities to be employed. There is a wide difference in the different materials which are mentioned as equivalent to each other; for example, an oleic acid soap and a phenol compound. Phenol when set free from its alkaline compound by an acid is quite soluble in water, while the true fatty acids set free from soap are practically insoluble in water, or nearly so. It would seem to me that very different quantities of these different substances would have to be selected according to their respective properties. It seems to me that it would be necessary to conduct a number of experiments to successfully practice the process, even if that be possible, and I have my doubts whether the process is practicable at all.

139-XQ. If the process of the Cattermole, Sulman and Picard patent No. 788,247 were to be carried out with an ordinary soap, what would be your understanding as to the amount of oleic acid to be liberated from

this soap by the mineral acid, that is, what quantity of the oleic acid eventually obtained in a free state would be necessary—a quantity great enough to cause the metalliferous mineral particles to agglomerate together, this being the quantity you referred to in connection with Catermole patents 777,273 and 777,274, or a greater or less quantity?

A. My only basis of calculation is the statement of Cattermole himself in patent No. 777,273, where he uses soap and oil. He says:

> "usually an amount of oil varying from 4 per cent. to 6 per cent. of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency and specific gravity for ready separation from the gangue."

Below that quotation he says:

> "When soap is employed, an amount varying from 3 per cent. to 5 per cent. of the weight of oil usually suffices."

Now I have not the slightest idea whether Cattermole used substantially the same proportions of fatty matter in the form of soap in patent 788,247 as he used in patent 777,273. He doesn't say in the later patent that he has to use any more than he did in the prior patent. As a matter of fact, 788,247 was applied for March 29, 1904, while patent 777,273 was applied for September 28, 1903, but the later patent does not state

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whether more or less fatty matter is required than in the earlier one.

Adjourned to Friday, December 13, 1912, at 10:30 in the forenoon, at the same place.

New York, December 13, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

Cross-examination continued:

(Answer to 139-XQ continued); It thus appears that the only one of the three patents referred to which specifies the amount of oil is patent No. 777,273, and the amount of oil specified is from 4 to 6 per cent. of the metalliferous mineral. In this patent the soap is used as an emulsifying agent and not as a substitute for oil, so the amount of soap to be used in connection with the oil has no relation to the amount of soap to be used when the soap is employed as a source of oleic acid and as a substitute for oil.

140-XQ. Referring to Dr. Byrnes' experiment with the Kirby process as described by him at page 161 of Defendant's Record, will you state how much blende could theoretically be floated in water by the 125 grams of kerosene used by Dr. Byrnes, without the assistance of any buoyancy derived from air, but relying exclusively upon the buoyancy imparted by the kerosene by virtue of its specific gravity?

A. I have reduced this problem to a formula, as follows:

Let X equal the volume of oil to be added to 1 volume of blende to reduce the specific gravity of the mixture to unity, that is, to the specific gravity of water.

The formula is as follows:

$$X = \frac{\text{Specific Gravity of Blende} - 1}{1 - \text{Specific Gravity of Oil.}}$$

This formula as applied to blende and kerosene oil is as follows:

$$X = \frac{4 - 1}{1 - 0.7935} = \frac{3}{0.2065}$$

The result of this equation is:

X = 14.65 volumes of oil.

Dr. Byrnes used 125 grams of kerosene. This would be sufficient to float 43.2 grams of sulphide of zinc or blende. The 500 grams of ore contain 30% of blende, which would be 150 grams of this mineral. If the 125 grams of oil floated 43.2 grams of blende, then there were 106.8 grams of blende not floated by oil, theoretically, of course. If Dr. Byrnes had used Kirby's maximum of oil, 375 grams or 75% of the ore, he could theoretically have floated 129.6 grams of blende, still leaving 20.4 grams not provided for.

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This calculation simply shows the amount of oil necessary to bring the mixture of oil and blende to the specific gravity of water. To secure flotation, it would, of course, be necessary to have a slight excess of the oil so as to reduce the specific gravity of the mixture below that of water.

141-XQ. Will you please state the specific gravity of the following oils: Crude petroleum, kerosene, lubricating oil, residuum, pine oil, sweet pine oil or pinoline, wood tar oil, cottonseed oil, eucalyptus, olive oil, turpentine, and oleic acid?

A.	Crude petroleum	0.8156 to 0.7978
	Kerosene	0.807 " 0.7935
	Lubricating oil	0.885
	Residuum	0.900
	Pine oil	0.9571 to 0.8696
	Sweet pine oil or pinoline	0.940
	Oil of wood tar	1.030
	Cottonseed oil	0.920 to 0.926
	Eucalyptus oil	0.850 " 0.925
	Olive oil	0.914 " 0.919
	Turpentine	0.865 " 0.875
	Oleic acid	0.900

These figures are not exact, because there are slight variations in the processes of different manufacturers.

142-XQ. If we have a known or assumed weight of a mixture of oil and zinc sulphide and desire to ascertain the proportions of zinc sulphide and oil, would not the solution of the following equations be a correct

method for determining the weight of oil and weight of zinc sulphide in the mixture:

w = Weight of Mixture
r = Specific Gravity of Mixture
x = Weight of Oil
m = Specific Gravity of Oil
y = Weight of Zinc Sulphide
n = Specific Gravity of Zinc Sulphide

$$w = x + y$$

$$\frac{w}{r} = \frac{x}{m} + \frac{y}{n}$$

A. In my opinion it is.

143-XQ. Now the specific gravity of zinc sulphide being 4, what would be the weights of zinc sulphide and an oil of a specific gravity of 0.8 in one gram of a mixture having a specific gravity of 1?

A. One of zinc blende to three of oil.

144-XQ. Will you answer the same question in reference to an oil having a specific gravity of 0.9?

A. It would be one of zinc sulphide to 6.7 of oil.

145-XQ. And will you answer the same question having reference to an oil of a specific gravity of 0.95?

A. It would be one of zinc blende to 15.7 of oil.

Cross-examination closed.

By Mr. Williams: The offer made during the deposition of Dr. Liebmann to repeat any of the

tests or experiments testified to by the witness is here repeated as to the experiments referred to by Dr. Chandler in his deposition.

Re-direct Examination by Mr. Williams:

146-RDQ. Does or does not the statement in the claim of the Froment Italian patent, that the oil must have an "oily fat body," exclude pine oil and sweet pine oil from the oil or oils thus described.

A. It does exclude them.

Re-direct Examination closed.

Deposition closed.

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MR. A. HOWARD HIGGINS, recalled, testified as follows:

Direct-examination by Mr. Williams:

23-Q. You have heretofore testified as to the production by you of an agitation mineral froth in March, 1905, in a cone mixer. Can you produce the original apparatus which you then used?

A. No. The original apparatus has been worn out and scrapped.

24-Q. Please produce a substantial reproduction of that apparatus, containing baffles such as were in that apparatus.

A. I now do so.

By Mr. Williams: The apparatus produced by the witness is offered in evidence and marked "Complainants' Exhibit, Cone Mixer."

The apparatus which was produced by Dr. Chandler as the modified oil feeding apparatus used by him in the test made by him of "Defendant's Exhibit, Apparatus of Patent No. 793,808," is also offered in evidence and marked "Complainants' Exhibit, Modified Oiling Apparatus."

25-Q. Is it possible for you to produce the series of cone mixers, and the series of spitzkasten such as are shown in the drawings of the patent in suit, which were the original apparatus used in the laboratory of Minerals Separation, Limited, in the year 1905?

A. No. This apparatus has also gone into the scrap heap.

26-Q. Dr. Liebmann describes certain experiments made by him in "Defendant's Exhibit, Apparatus of Patent No. 793,808," and in his experiments 1 and 2, described on page 418 of Complainants' Record, he says that the oil was sprayed in by air. Were you present when these experiments were conducted, and, if so, will you please state what apparatus was used for obtaining the oil feed which he described?

A. I was present, and saw "Complainants' Exhibit, Modified Oiling Apparatus," being used.

27-Q. Dr. Liebmann, on page 387 on Complainants'

Record, describes an experiment carrying out the Everson invention and says that the mixture was run into a washing-out vessel and the concentrate removed by a constant overflow of water, but does not say whether or not the water in the washing-out vessel was acidulated. Were you present, and was the water acidulated?

A. I was present and saw the water acidulated before use.

28-Q. Dr. Chandler has described in his testimony an experiment carrying out the instructions of the Everson patent as to the second method of treatment described therein. Have you had an assay made of the concentrates and tailings which were obtained as a result of that experiment, and if so, will you kindly give the figures as to zinc?

A. Yes, I had assays made by Constant & Company, the results being as follows:

Original ore,	Zinc	21.8%	Insolubles	58.2%
Concentrates,	"	15.8%	"	67.6%
Tailings,	"	22.0%	"	57.6%

It is stipulated that this assay will be accepted as evidence without the production of the assayer.

29-Q. I have had a drawing made on a smaller scale following the large blue print "Complainants' Exhibit, Drawing Australian Model Plant." Please state whether or not this smaller scale drawing, which I now produce, represents this plant as used in Minerals Separation laboratory.

A. Yes.

30-Q. I noted in the original drawing that four holes were shown in each of the walls between the agitation boxes and according to your instructions I had three of these closed by plugs, leaving a single opening for the liquid to flow from agitation box to agitation box. Was this a proper representation of the thing as used, and what was the purpose of the provision of four holes?

A. Yes. The four holes were provided for the purpose of experiment, in finding the effect of the passage of the liquid from agitation box to agitation box in using different combinations of openings.

> "It is stipulated that the drawing now produced may be substituted in place of the large blue print marked "Complainants' Exhibit, Drawing Australian Model Plant," as an exhibit herein, the blue print, however, to be produced upon demand.
>
> It is also stipulated that the drawing marked "Complainant's Exhibit, Froment Plan," be replaced in evidence by a reduced drawing thereof now produced and similarly marked, the original, however, to be produced at any time upon demand.
>
> The same stipulation is made as to "Complainants' Exhibit, Froment Drawing A," and as to "Complainants' Exhibit, First Tracing of Slide Machine."

A. Howard Higgins.

31-Q. Have you made tests in a modern continuously-operating plant for the production of the agitation froth, using cottonseed oil in the proportions used by Dr. Byrnes in his second test in the slide machine alleged to be in operation of the Froment British patent described by him on pages 165 and 166? If so, please give the details of this test.

A. Yes, I have made tests at Butte, Montana, in a plant substantially the same as that shown in the drawings "Complainants' Exhibit, King John's Court Standard Plant," with the exception that there were six spitzkasten instead of five. The apparatus is a small one, having a capacity of 10 lbs. of ore per minute. The ore used was from the Elm Orlu mine, which is adjacent to the Black Rock mine of the Butte & Superior Copper Company. With the exception of the presence of some clay in the ore, it was practically identical with the Black Rock ore. After being crushed to 80 mesh, it was fed to the plant at the rate of 10 lbs. per minute, sulphuric acid and cottonseed oil being fed in the proportions used by Dr. Byrnes in his second test. In about three minutes the plant had settled into a permanent condition. The float on the first spitzkasten was copious, being about one inch to an inch and a half deep, and though oily in appearance when closely examined, did not differ in appearance from the usual agitation froth at a distance of a few feet. These floats were exceedingly dense and occasionally fell down in large masses. The tailings contained some

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granules, and did not indicate a satisfactory recovery. Samples were taken of these products and assayed:

Original ore,	Zinc	20.41%	Insolubles	59.95%
Concentrates,	"	47.54%	"	11.82%
Tailings,	"	12.94%	"	72.24%

giving a recovery of 50% of the zinc in the concentrates.

The small plant that I used is nominally a five-ton plant, although its maximum capacity is seven tons per day. This plant is not intended for commercial use in treating zinc ores, being only a testing plant. The percentage of oil used in the test was 3.6 on the ore, corresponding to the 20cc. of cottonseed oil used by Dr. Byrnes.

Direct-examination closed.

No cross-examination.

Deposition closed.

A. HOWARD HIGGINS.

By Mr. Williams: The following documents, heretofore marked for identification, are offered in evidence and entitled respectfully "Complainants' Exhibit" and the title hereinafter given by which they were identified when marked for identification:

A. Howard Higgins.

"Cable, Hoover to Hyde, January 18, 1910;"

"Cable, Hyde to Hoover, January 20, 1910;"

"Cable, Hoover to Hyde, January 21, 1910;"

"Cable, Hyde to Hoover, January 24, 1910;"

"Letter, Minerals Separation to Hyde, March 2, 1910;"

"Hyde Acceptance, March 3, 1910;"

"Cable, Minerals Separation to Hyde, Dec. 8, 1910;"

"Cable, Hyde to Minerals Separation, December 9, 1910;"

"Letter, Minerals Separation to Hyde, November 23, 1910;"

"Hyde Report, January 8, 1911;"

"Copy Memorandum re Managership of Minerals Separation American Syndicate, Limited;"

"Letter, Hyde to Minerals Separation American Syndicate, January 17, 1911;"

"Letter, Minerals Separation to Hyde, February 1, 1911:"

It is noted that, as to those of the above documents hich were produced by the defendant, by stipulation, e original documents produced by him have been turned to him and replaced by copies to have the same rce and effect as the originals, the originals to be oduced upon demand.

It is further stipulated, as to all printed or writ-n documents produced in evidence, that the copies

thereof in the printed records shall take the place of the original documents, the originals to be produced upon demand.

Adjourned to Saturday, December 14, 1912, at 10:30 in the forenoon, at the same place.

New York, December 14, 1912.

Met pursuant to adjournment.

Present—Counsel as before.

GEORGE A. CHAPMAN, recalled, having been duly cautioned and sworn, deposes as follows:

Direct-examination by Mr. Williams:

246-Q. Are you the same George A. Chapman who has heretofore testified as a witness for the complainants?

A. I am.

247-Q. I now show you two exhibits marked, respectively, "Complainants' Exhibit, Reproduction of Froment Mixer" and "Complainants' Exhibit, Reproduction of Froment Vat with Coil." Please state whether or not these exhibits are reproductions of parts of the Froment apparatus which were in the laboratory of Sulman and Picard and of Minerals Separation, Limited, during the year 1904, and which, as you have heretofore testified in answer to 4-Q, you tested.

A. These exhibits are an almost exact reproduction of the old Froment apparatus which I used about 1904.

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The Froment mixer appears to be a little bit larger in diameter, but the rotating devices inside are almost exactly the same as in the old apparatus. The only difference that I can see is that screws hold the teeth in place instead of rivets. My memory is refreshed by seeing this device and I want to correct a statement that I have made before that the agitator consisted of wire beaters. My memory was confused at that time because of the Robson & Crowder mixer which we had in the laboratory at a later time than when I used the Froment mixer and in which there were stout wires something like a grid. We also had in the laboratory a mixer like an egg beater. That was used in connection with the tests on breaking down Cattermole granules. The memory of these different apparatus confused me, but now that I have seen this Froment reproduction, I am very sure that the old Froment mixing device has been here substantially reproduced.

I may add, however, that there was a sort of hopper on the side of the old Froment Mixer, which I understand from Mr. Higgins it was not deemed necessary to reproduce.

The vat with coil agrees exactly with the description which I gave before. As I think it over carefully, it may be possible that the points of the rake were sharpened in the old Froment apparatus, but I am sure this would not make any difference.

248-Q. I call your attention to your answer to 39-XQ in your former deposition, appearing at page

208 of Complainants' Record, and ask you whether with the proportions there stated, 20 grams of ore and 70 of water, you would have added oil "by drops equivalent to 1½ to 2 lbs. of oil per ton of ore?"

A. No. With such an amount of ore, one drop of oil would be more than 1½ to 2 lbs. to the ton. The only way to get a small enough quantity of oil for such a test would be to use a soap solution, which could be made sufficiently weak to carry the fraction of a drop of oil that would be required in such a test. This would be decomposed by the sulphuric acid and the oil set free. I am quite sure that I have made tests that way, although tests of this kind are only rough tests to indicate the possibility of obtaining the agitation froth with an ore. Never at any time have I used this method for a quantitative test. The slide machine is the usual apparatus for the first quantitative test.

249-Q. Have you made tests in a modern, continuously operating plant for the production of the agitation froth, using cottonseed oil in the proportions used by Dr. Byrnes in his second test in the slide machine alleged to be an operation of the Froment British patent and described by him on pages 165 and 166 of Defendant's Record? If so, please give the details of this test or tests.

A. I made a test in the London Standard plant. This is the same plant described by Dr. Liebman in his testimony page 499 of Complainants' Record, contain-

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ing eight agitators and six flotation boxes and it was used in the same conditions as when Dr. Liebmann used it in his London experiments. This is known as a fifty ton plant and could be worked at that capacity at a mine, but it is used for testing purposes only and never run to its full capacity.

The ore that I used was Broken Hill tailings, containing about 18% of zinc and about 5% of lead. This ore was crushed to pass through an 80 mesh screen. The plant was operated for an hour and 1680 lbs. of ore were fed in during this period. Cottonseed oil was used in the proportion of 3.6% of oil on the weight of the ore and the acid consumption was 0.37% on the weight of the ore. (1cc. is 1.8 grams, which is 0.368% of 492 grams of ore). The temperature of the water was maintained at 70° Fahrenheit.

An oily float was obtained, some of which was carried below the surface of the water. I made adjustments so as to carry this float over; certainly more than 30% of it was carried below the surface of the water. There were large, clean, oil-film bubbles in it and it did not look at all to me like an agitation froth such as is obtained under normal and economical conditions of oil consumption. The float looked oily and it was oily to the touch, whereas the normal agitation froth does not show the presence of oil nor can you feel that there is any oil in it.

The tailings were oily and dirty and contained incipient granules. I took some of these tailings and

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rolled them in a Gabbett without baffles and obtained good granules.

I separated the concentrates which overflowed from the six flotation boxes and had them separately assayed, and also had the tailings assayed.

The returns were as follows:

EXPERIMENT No. 1.

	Weight		Pencentages		% Recov.	
	Total Lbs.	Insol.	Zinc	Lead	Zinc	Lead
1st Conc.	26.6	14.1	28.8	9.0	2.52	2.92
2nd Conc.	21.7	12.6	29.9	8.9	2.14	2.35
3rd Conc.	14.2	11.0	31.4	8.8	1.47	1.52
4th Conc.	25.2	11.2	30.7	8.9	2.54	2.72
5th Conc.	21.2	20.5	26.7	7.3	1.87	1.87
6th Conc.	20.6	14.2	30.9	8.5	2.1	2.12
Tailings	1550.5	——	17.1	4.6	87.5	86.6

The recoveries of zinc and lead in the total concentrates were, zinc, 12.6%; lead, 13.6%.

The amount of sulphuric acid used by Dr. Byrnes was less than the normal amount used in the agitation froth process for Broken Hill tailings, and so I ran another test, using an acid consumption of 25 lbs. to the ton, which is rather more than the normal acid requirement of this ore when using the agitation froth process under proper conditions. Everything else, as to temperature, time, materials, etc., was exactly the same as in the test just described. The results were assayed and the assay returns were as follows:

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EXPERIMENT 2.

	Weight		Percentages		% Recov.	
	Total Lbs.	Insol.	Zinc	Lead:	Zinc	Lead
1st Conc.	71	6.0	37.9	9.0	9.03	8.73
2nd Conc.	51	5.8	38.2	9.0	6.58	6.27
3rd Conc.	39	7.3	36.3	8.7	4.8	4.63
4th Conc.	34	8.4	35.6	8.5	4.1	3.95
5th Conc.	27	11.2	34.6	8.1	3.12	3.00
6th Conc.	27	5.2	38.6	8.5	3.5	3.13
Tailings	1431	——	14.2	3.6	68.6	70.25

The recoveries of zinc and lead in the total concentrates were, zinc, 31.13%, and lead, 29.71%.

The results of this second test were a little better than of the first test. They were both wasteful in the great quantities of oil used and absolute failures as to the results.

I took some of the tailings from my test No. 2 above described and made granules from them by rolling them in a cone mixer or Gabbett without baffles. I have brought a specimen of these granules with me and I now produce it.

The floating material obtained in this second test was practically the same as in the first, only it contained more mineral and less gangue.

After I had made these two tests, it was suggested to me by our patent agent, Mr. Ballantyne, that I would more nearly parallel Dr. Byrnes' tests by having less agitation. Dr. Byrnes agitated in a slide machine for thirty seconds for his first agitation and from ten ~~or~~ to

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twenty seconds each for his subsequent agitation. We usually agitate one and a half to two minutes for the first agitation in the slide machine, and half a minute to one minute for subsequent agitations. To repeat this condition of under agitation, I made another test with proportions of all material, temperature and time the same as in my experiment No. 1, but using only six agitators, one agitator for each of the six flotation boxes. The results were a slight improvement on the results in test No. 1. The floating material was the same and the tailings contained incipient granules which I granulated as I have described before. The results were assayed and the assay returns were as follows:

EXPERIMENT 3.

	Weight	Percentages			% Reco.	
	Total Lbs.	Insol.	Zinc	Lead	Zinc	Lead
1st Conc.	25.3	12.5	30.5	7.8	2.36	2.06
2nd Conc.	37.6	10.4	33.3	7.6	3.84	3.00
3rd Conc.	31.0	10.6	34.1	8.0	3.24	2.60
4th Conc.	46.3	10.8	34.1	7.9	4.84	3.82
5th Conc.	42.0	14.5	33.0	8.1	4.25	3.56
6th Conc.	23.0	11.7	33.6	7.5	2.36	1.81
Tailings	1474.8	——	17.5	5.4	79.1	83.2

The recoveries of zinc and lead in the total concentrates were, zinc, 20.89%; lead, 16.85%.

It is stipulated that these assays will be accepted as evidence without the production of the assayer.

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By Mr. Williams: The specimen of granules produced by the witness is offered in evidence and marked "Complainants' Exhibit, Cattermole Granules, Chapman London Test."

250-Q. Have you also made a test in the same plant using oleic acid in the proportion of 1.8% on the ore, and the proportion of sulphuric acid given by Dr. Byrnes and used by you in your experiments 1 and 3 with cottonseed oil? If so, please describe the experiment.

A. I made this test using a very good oleic acid, purer than the ordinary red oil of commerce. The floats were very bulky and contained a very high proportion of gangue and very little enrichment of the crude ore took place. The procedure was altogether wasteful, and the result of no commercial value at all. If the agitation froth process, when properly used, gave any such results as this, it would never have been adopted for practical use. The float obtained was oily in appearance and oily to the touch, but not as oily as in the other tests where I had used cottonseed oil and had used twice as much oil.

I used the same Standard plant with six agitators and six flotation boxes in operation, so as to come as near as possible to Dr. Byrnes' conditions. The time and temperature, and quantity of ore were the same as before, and the sulphuric acid was the same as in my cottonseed oil tests Nos. 1 and 3. The concentrates

were separately assayed and the tailings were assayed. The assay returns were as follows:

EXPERIMENT 4.

	Weight Total Lbs.	Percentages Insol.	Zinc	Lead	% Recovered Zinc	Lead
1st Conc.	138	25.3	24.5	6.9	10.95	10.80
2nd Conc	284	30.0	22.3	6.2	20.55	20.15
3rd Conc.	151	30.3	21.9	6.4	10.70	11.05
4th Conc.	152	29.5	22.6	6.6	11.17	11.52
5th Conc.	146	33.8	20.5	6.0	9.75	10.01
6th Conc.	99	34.4	20.7	5.7	6.66	6.47
Tailings	710	——	13.1	3.7	30.22	30.00

The recoveries of the zinc and lead in the total concentrates were, zinc, 69.78%; lead, 70.40%.

I would say that these recoveries were in a concentrate of so low a grade that it would really not be considered a concentrate. If you were to take a ton of ore and shift it from one bin to another, you would have 100% of your mineral in the second bin.

251-Q. Did you analyze the gas in the float in any of these experiments? If so, please give the results of your analysis.

A. In one instance, as to my experiment No. 1, with cottonseed oil, I made careful gas analyses with an exact repetition of this run. It took quite some time to collect the gas in the float, but I got a fair specimen from each of the first four flotation boxes. The actual volume of air or gas in the floats was very much less than

in the normal agitation froth, but my tests showed that the proportion of CO_2 in this gas was less than we have found it in many gas analyses of the normal agitation froth and kept on getting less in the successive boxes. I made two series of tests to correct any possible error in one of them, and I give below the results obtained from each analysis and the average of the two analyses:

	1st Analysis.	2nd Analysis.	Average
1st Box CO_2	2.8%	3.1%	3 %
2nd Box CO_2	1.4%	1.8%	1.6%
3rd Box CO_2	1.1%	0.9%	1 %
4th Box CO_2	0.6%	0.8%	0.7%

I used all the sampling glasses that I had for these analyses and had no further glasses for the fifth and sixth boxes.

252-Q. Did you make any tests with the proportions given in the Froment British patent?

A. Yes, I made two tests in the ordinary slide machine with 500 grams and 400 grams of Broken Hill tailings and other quantities in proportion.

First I determined how much oil would make a layer in an 80cc. test tube of the oil which I used, which was Winter dark oil, the oil which was ordinarily used in the Elmore bulk oil flotation process at the time of the year, the present month of December, when I made the test. I found that 41 drops of Winter dark oil or 1.4cc. or 12.6% of 10 grams of ore was the smallest

amount to produce a layer. I noted the temperature of the room at the time, which was 65° Fahrenheit.

1st Experiment, Froment. I used 500 grams of Broken Hill tailings crushed to pass through a 60 mesh screen, and 50 grams of calcite similarly crushed; 1500cc. of water; 150cc. dilute sulphuric acid (containing 50 grams of mono-acid or concentrated sulphuric acid); and 70cc. of Winter dark oil. I mixed the ore, calcite and water first to wet the ore and calcite. The acid and oil were then added and I put on the full current of the motor for two seconds. There was a violent evolution of gas, which caused a portion of the contents of the slide machine to be thrown out, and because of this loss, I abandoned the test. As a matter of fact, the float rose more than 7½ inches, which was the distance from the water level to the top of the machine, and overflowed.

2nd Experiment, Froment. Here I used only 400 grams of ore and reduced all other quantities in the same proportion. The quantities used were as follows:

400	grams Broken Hill tailings
40	" calcite
1200cc.	water
120cc.	dilute sulphuric acid (40 grams acid)
56cc.	Winter dark oil.

I mixed the ore, water and limestone as before, then added the acid and oil and agitated for two seconds as before. The float rose to within two inches from the

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top of the slide machine, but subsided to a float of about four or five inches in thickness after the violent evolution of the gas had ceased. After this violent evolution had ceased and the float had subsided, I took a sample of gas from the float and made two analyses of it as before. The first analysis showed that the gas in the float was 97.3% carbon dioxide; the second analysis gave 97% of carbon dioxide. The average of the two analyses was 97.15% carbon dioxide. My analysis of these gases determined the amount of carbon dioxide present. The rest of the gas, less than 3 per cent, was probably air. There was no odor of sulphuretted hydrogen in the gases. This was true as to all of the tests I have described in this deposition.

253-Q. Did you notice any odors during any of these tests?

A. Yes. During the cottonseed oil tests there was an unpleasant odor which had the effect of making me sick, and those working with me showed evidence of sickness and complained of sickness.

254-Q. Did you observe any effects on the apparatus of the use of cottonseed oil and oleic acid in the proportions used in these tests?

A. Parts of the plant were left in a dirty and greasy condition, which made it necessary to scrub all accessible parts with alkaline soft soap solution after the completion of the tests. After each series of tests we circulated a nearly boiling solution of weak alkaline soft soap through the entire plant, using in each lot

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50,000 gallons of water and circulating it around for about twelve hours. All of these efforts did not clean the plant so that it could be used for normal agitation froth working. We then put several charges of ore pulp through the plant and finally restored it to condition for testing under normal conditions. It was nearly a fortnight before the plant was again in working order.

255-Q. Does normal agitation froth operation make a plant greasy as did the tests you have described?

A. No. The oil disappears. The dirt in the plant is never greasy.

256-Q. I call your attention to Q-56 and Answer in the deposition of the defendant, James M. Hyde, Defendant's Record, pages 73, 74. What have you to say as to this?

A. Mr. Hyde appears not to be well informed as to the wide usefulness and application of the agitation froth process. It is applicable to the three copper sulphides appearing in ores, these three forms being chalcopyrite, chalcocite and copper glance. Mixed sulphide ores treated by it are usually marketable as concentrates, for example all Broken Hill concentrates are sold as a mixed concentrate of zinc and lead. The Swedish ore of the Saxbergets mine, when treated by the agitation froth process, produces a mixed concentrate consisting of zinc blende, galena (lead sulphide), and pyrrhotite (magnetic sulphide of iron). The pyrrhotite is separated by magnetic treatment and the zinc blende

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and galena are separated on water concentration tables, as described by me in answer to 87-Q (Complainants' Record, pages 196, 197).

As a matter of fact, the smelters penalize Broken Hill concentrates if they do not contain with the blende a fair proportion of lead.

257-Q. Do you know of any instance where cottonseed oil is used in the agitation froth process?

A. No. It costs more than oleic acid and is not as well suited as oleic acid. We have never considered it as a likely oil for this process.

Direct-examination closed.

No cross-examination.

Deposition closed.

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By Mr. Williams: I now produce the Slide Machine which was used in Dr. Chandler's experiments for his testimony in the *prima facie* case, as well as in subsequent experiments at New York City, and which has been in my custody since its arrival in America, and offer it in evidence pursuant to agreement of counsel appearing at page 95 of Defendant's Record, and it is marked "Complainants' Exhibit, Slide Machine."

A stipulation of counsel is here recorded that as to "Complainants' Exhibit, Nutter Report, July

28, 1910," all portions of the body of the report preceding the paragraph entitled "Recoveries" are withdrawn from evidence.

By Mr. Williams: I offer in evidence a stipulation as to extension of License and Option to Minerals Separation American Syndicate, Limited, and it is marked "Complainants' Exhibit, Stipulation."

Complainants here close their testimony.

Complainants' Record

VOLUME III

EXHIBITS

No. 835,120. PATENTED NOV. 6, 1906.

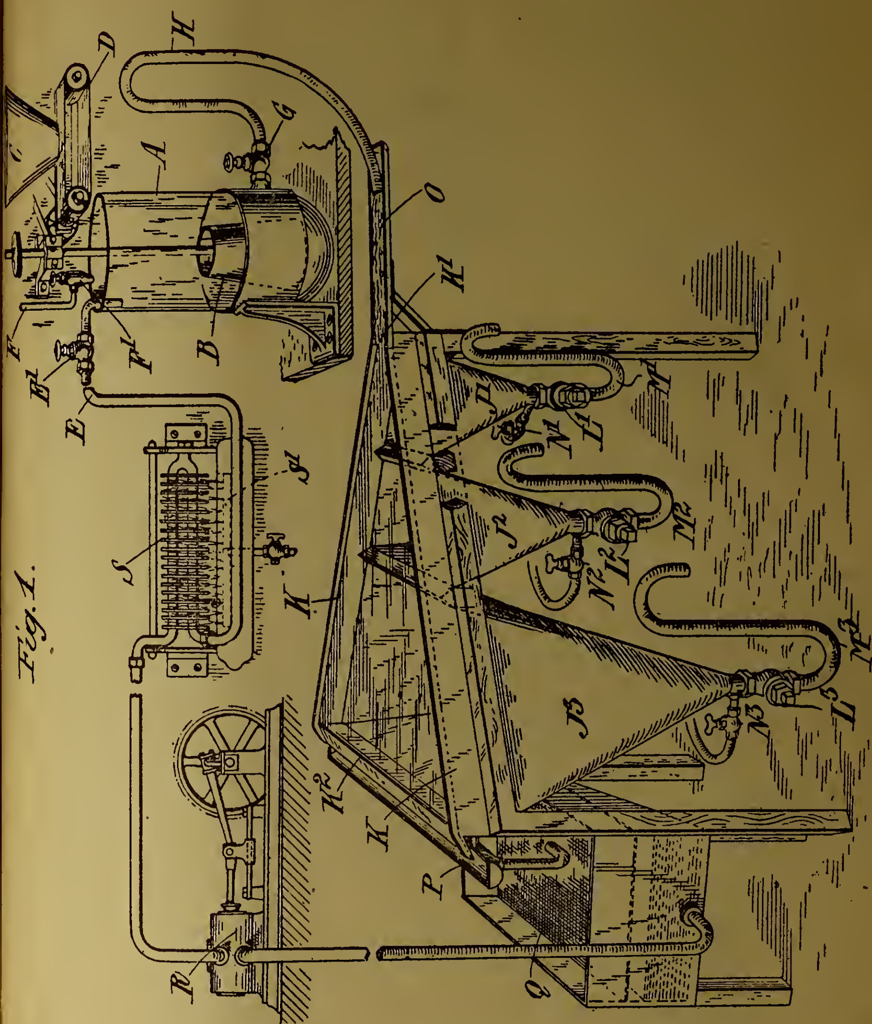
H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905.

2 SHEETS—SHEET 1

Fig. 1.



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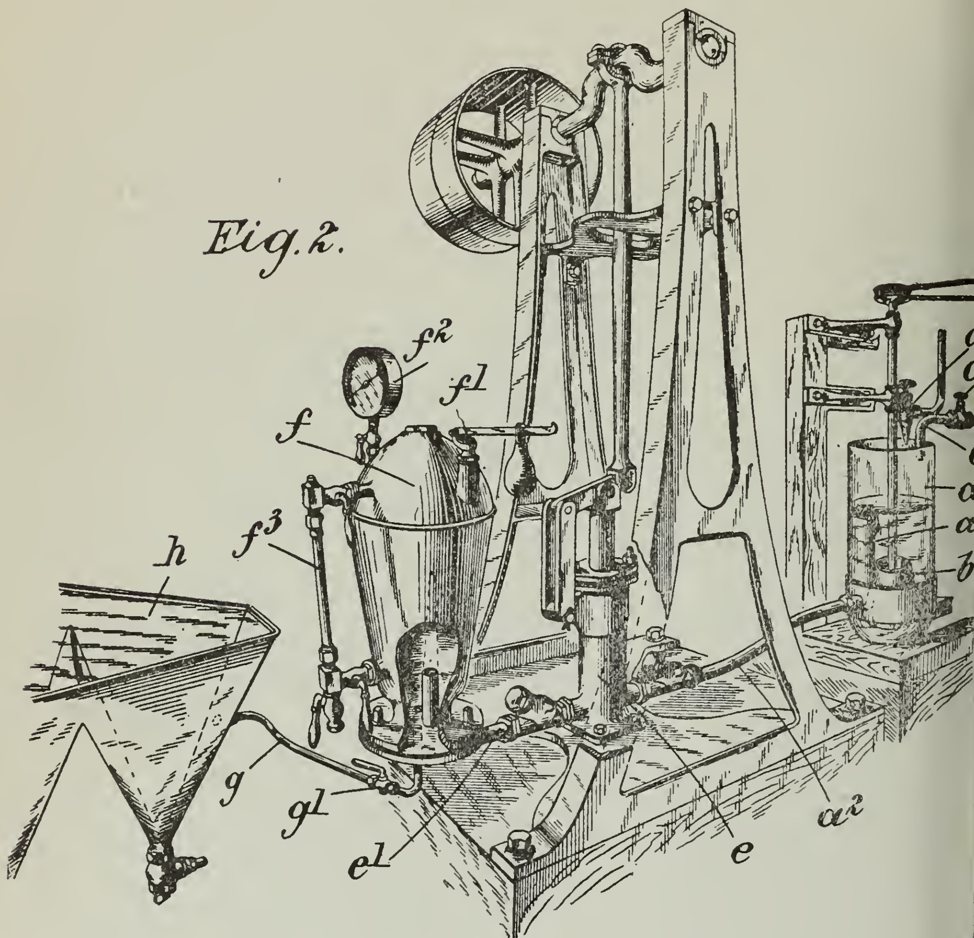
ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905

3 SHEETS—SHEET 2

Fig. 2.



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UNITED STATES PATENT OFFICE.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, AND JOHN BALLOT, OF LONDON, ENGLAND.

ORE CONCENTRATION.

No. 835,120. Specification of Letters Patent. Patented Nov. 6, 1906.

Application filed May 29, 1905. Serial No. 262,889.

To all whom it may concern:

Be it known that we, HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, subjects of the King of England, residing in London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors. Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a fraction of one per cent. up to one per cent. of sulfuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present. Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed. The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface, while larger particles have less tendency to be included in the froth. The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore. An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet is finely powdered and mixed with water containing a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt, conveniently sulfuric acid or mine or other waters containing ferric sulfate. To this is added a very small proportion of oleic acid, (say from 0.02 per cent to 0.5 per cent on the weight of ore.) The mixture is warmed, say, to 30° to 40° centigrade and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped, a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air-bubbles introduced into the mass by the agitation, such bubbles or air-films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical.

If the ore were crushed to ninety mesh to the linear inch, (half of which ore will pass through one hundred and fifty mesh sieve,) the froth may contain about seventy per cent. to eighty per cent. of the metalliferous matter

present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise. After subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali, which removes the oleic acid in the form of a solution of soap.

If desired, the oleic acid used in the first instance may be produced *in situ* in the pulp by decomposing a dilute soap solution with mineral acid, as described in the previous patent, No. 777,274, cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron, or other salts are present in small quantity during the production or on the breaking down of the froth with alkali. Such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation, much the same as the fatty acids do

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking-table, convex buddle, or the like, whereon the mineral is exposed to a free-air surface which exposure may be increased by the application of air-blast or air-jets or the like and thereafter brought onto the edge or surface of liquid, whereby the metalliferous matter floats and is separated from the gangue, which sinks, as described in the specification of our previous United States application Serial No. 246,637, filed February 20, 1905.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied; but, generally speaking, the froth will separate the slime mineral while the larger particles are recovered by the latter method.

In the accompanying drawings, Figure 1 is a diagram in perspective illustrating one form of apparatus suitable for carrying this invention into practice, and Fig. 2 represents in perspective an apparatus for carrying out a secondary step in the process.

Referring to Fig. 1, a mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E, controlled by a tap E', delivers circuit-water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus. In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may, if desired, be run in a thin layer over a smooth slightly-inclined plane.

The froth-separating apparatus compri several (say three) pointed boxes J' J² which open at the top into a horizontal cha nel consisting of side walls K. The chan has a narrow inlet K' and spreads out to wide outlet K². The pointed boxes J' J² have fullway-cocks L' L² L³ at the botto leading to swan-neck discharge-pipes M' M³. An upcurrent of water may be led in the bottom of each box through a tap N³ N³.

The boxes are all filled with circuit-wat The pulp from the vessel A is distributed ho zontally from the flat trough O through inlet K'. The heavy sands and coarser p ticles of mineral sink into the first box from which they are led to a shaking-ta convex buddle, or the like, to be treate above described. The middlings or med sands fall into the box J², and if they con any mineral may be removed for fur treatment by agitation. The upcurrent water from the taps N' N² prevents the d osition of any slime in these boxes. fine sands or gangue slimes settle in the box J³, from which they are discharged waste or further treatment.

The slime mineral in the form of frot scum floats from the liquid and is carried the stream over the outlet K² into a laun P and thence to a filter Q, where the me liferous matter is removed from the circ water, which is returned to the vessel A l pump R. The circuit-water may be brou to the proper temperature by passing through a heater S, having a burner S', be admitting the water to the vessel A.

An alternative method for the recover any sunk-oiled metalliferous matter wh may be deposited in the second and t spitzkasten is as follows: The products pended in circuit liquor are removed f the spitzkasten and placed in a vesse which they are submitted to an additi pressure of air or other gas of from, say, to two atmospheres or over. On relie such pressure the bubbles of air or other so generated throughout the mass at sweep to the surface thereof all the met erous matter in the form of a froth which be separated as before. This idea is claimed broadly in this case, but forms subject-matter of an application filed b on January 9, 1906, Serial No. 295,326.

Referring to Fig. 2, a mixing vessel which there may be several in series) is vided with a rotatable stirrer *b* Cru ore or similar finely-divided mineral i into the vessel *a*. A pipe *c*, controlled tap *c'*, delivers circuit-water to the v and in cases where oil is used the oil is i duced through the pipe *d* in quantity cient to produce a thin coating of oil on mineral particles for which oil has an affi

The pulp mixed with oil escapes ove

lip of the discharge-conduit a' and passes through the pipe a^2 to a pump e. Hence the pulp is pumped through discharge-pipe e' into the closed chamber f, which is constructed to withstand a considerable internal pressure and is provided with a safety-valve f', the pressure-gage f^2, and a gage-glass f^3 to indicate the level of the pulp in the chamber. An outlet-pipe g, having a cock g', leads to a series of spitzkasten h, filled with circ[illegible]-water.

The operation is as follows: The cock g' is closed. Pulp is pumped into the chamber f, which contains air or other gas, and the pumping is continued until the pressure in the chamber rises to, say, fifty to one hundred pounds per square inch. The pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid the cock g' is opened and the pulp is discharged into the open spitzkasten h, where the liquid is of course under atmospheric pressure. The pump e may be stopped during this discharge. The whole of the mineral to which air bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten, and the floating material is thus removed and separated from the gangue, which remains sunk or suspended in the liquid.

per cent. on the
agitating the mi
mineral matter fo
rating the froth fr
tion.

4. The herein-c
trating ores whic
ing the ore, mixi
water, adding a s
substance having
metalliferous ma
tion of one per ce
mixture, agitatin
coated mineral m
separating the fr
flotation, and r
from the mineral.

5. The herein-c
trating ores whi
powdered ore wit
portion of oleic a
per cent. on the
until the oleic aci
cient contact w
formed a froth th
froth from the rem

6. The herein-c
trating ores whi
powdered ore wit
tion of one per ce
small proportion
0.02–0.5 per cent
mixture until the

oil, agitating the mixture to form a frot and separating the froth.

10. The process of concentrating powder ores which consists in separating the miner from the gangue by coating the mineral wi oil in water containing a small quantity of o warming the mixture, agitating the mixtu to form a froth, and separating the froth.

11 The process of concentrating powder ores, which consists in separating the miner from the gangue by coating the mineral wi oil in water containing a small quantity of o and a quantity of acid insufficient to cau chemical action on the metalliferous mine als present, agitating the mixture to form froth, and separating the froth.

12. The process of concentrating powder ore which consists in separating the minera from gangue by coating the minerals with in water containing a fraction of one per cen of oil on the ore, agitating the mixture cause the oil-coated mineral to form a frot and separating the froth from the remaind of the mixture.

13. The herein-described process of co centrating ores which consists in finely po dering the ore, mixing it with water contai

Complainants' Exhibit—Assignment.

UNITED STATES. No. 835120.

WHEREAS, we, HENRY LIVINGSTONE SULMAN and HUGH FITZALIS KIRKPATRICK-PICARD both of 44, London Wall, in the City of London, England, Metallurgists and JOHN BALLOT of 62, London Wall, in the City of London, England, Merchant, did obtain Letters Patent in the United States for "IMPROVEMENT IN ORE CONCENTRATION"
which Letters Patent are numbered 835120 and bear date the 6th day of November One thousand nine hundred and six.

AND WHEREAS we are now the sole owners of the said Letters Patent and all rights under the same,

AND WHEREAS MINERALS SEPARATION LIMITED of 62, London Wall, in the City of London, England is desirous of acquiring the entire interest in the same.

NOW THEREFORE TO ALL WHOM IT MAY CONCERN, be it known that for and in consideration of the sum of One Dollar to us in hand paid, the receipt of which is hereby acknowledged, we the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have sold assigned and transferred and by these presents ~~to~~ do sell assign and transfer unto the said MINERALS SEPARATION LIMITED the whole right title and interest in and to the said

Complainants' Exhibit—Assignment.

"IMPROVEMENTS IN ORE CONCENTRATION" and in and to the Letters Patent therefor aforesaid; the same to be held and enjoyed by the said MINERALS SEPARATION LIMITED for its own use and behoof and for the use and behoof of its legal representatives, to the full end of the term for which said Letters Patent are or may be granted, as fully and entirely as the same would have been held and enjoyed by us had this Assignment and Sale not been made.

IN TESTIMONY WHEREOF we have hereunto set our hands and affixed our Seals at London, England, this seventh day of December, 1909.

HENRY LIVINGSTONE SULMAN (L. S.),
HUGH F. K. PICARD (L. S.),
JOHN BALLOT (L. S.).

2 *Witnesses,*

HARRY SHIRLY,
H. C. HANKINS.

City of London, England,
Kingdom of Great Britain and Ireland, } ss.:

Before me personally appeared HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK PICARD and JOHN BALLOT, to me personally known and known to me to be the individuals described in and who executed the foregoing instrument,

and they severally acknowledged to me that they executed the same for the uses and purposes therein set forth and that the same was their free act and deed.

WITNESS my hand and official seal at London, England, this Eighth day of January, A. D., 1912.

(Seal of U. S. Consulate)

RICHARD WESTACOTT,
Vice and Deputy Consul-General of the United States of America, London, England.

(American Consular Service Fee Stamp $2.00).

Department of the Interior,

UNITED STATES PATENT OFFICE.

RECEIVED AND RECORDED on the 28th day of August, 1911, in Liber Y, 87, page 80 of Transfers of Patents.

(Seal of United States Patent office.)

IN TESTIMONY WHEREOF, I have caused the seal of the Patent Office to be hereunto affixed.

E. B. MOORE,
Commissioner of Patents.

Complainants' Exhibit, License Agreement.

(A)

THIS AGREEMENT made the tenth day of October, One thousand nine hundred and ten between MINERALS SEPARATION LIMITED having its registered Office at 62 London Wall in the City of London (hereinafter called "the Company") of the one part and MINERALS SEPARATION AMERICAN SYNDICATE LIMITED having its registered Office at 62 London Wall aforesaid (hereinafter called "the Syndicate") of the other part WHEREAS the Company are the owners of various processes for the separation of minerals from gangue covered by patents taken out in the United States of America and in the Dominion of Canada short particulars of which are contained in the Schedule hereto AND WHEREAS the Syndicate has been formed for exploiting and for conducting experiments for the treatment of ores by the Company's said processes in the United States of America and Dominion of Canada and also for acquiring and turning to profitable account ores tailings dumps and also mining and other properties believed to contain minerals amenable to treatment by the Company's processes with a view to utilizing such processes in the United States of America and Dominion of Canada in connection therewith and of securing options of purchase of ores tailings dumps and mining and other suitable properties or substantial interests therein and otherwise giving effect to the objects of the Syndicate as

defined by its Memorandum of Association AND WHEREAS the Syndicate has been registered in England under the Companies (Consolidation) Act of 1908 with a nominal capital of Fifty-two thousand five hundred pounds divided into Fifty thousand "A" shares of One pound each and Fifty thousand "B" shares of One shilling each AND WHEREAS by the Syndicate's Articles of Association it is provided that the Syndicate shall enter into and carry into effect an Agreement therein referred to being these presents NOW IT IS HEREBY MUTUALLY AGREED between the parties as follows:

1. For the consideration hereinafter appearing the Company doth hereby give and grant unto the Syndicate (1) the sole and exclusive right license power and authority to apply use and exercise in the United States of America and in the Dominion of Canada but not elsewhere all or any of the inventions processes apparatus plant or machinery described in the Specifications of the Letters patent of the United States of America and of the Dominion of Canada shortly described in the Schedule hereto for the term of two years from the date hereof subject nevertheless to any compulsory licenses which may be granted pursuant to the order or direction of any Court of Law or other competent authority in either of the said countries but so that any royalties or other considerations payable under any such compulsory licenses shall belong to and

be divisible and payable as follows: So much of the same as arises and is payable in respect of the said term of two years or other the period during which the License hereby granted is in force (or in the case of a lump sum consideration so much thereof as is fairly apportionable to the said term or period) shall belong and be paid to the Syndicate and the balance shall belong to the Company provided that in the event of the said Letters patent being purchased under the option hereinafter given to the Syndicate and of the said purchase being duly completed the Company shall assign and make over to the new Company hereinafter referred to the portion of the said royalties and considerations belonging to the Company as aforesaid (2) The option or right to purchase the said American and Canadian Letters patent under and in accordance with Clause 13 hereof.

2. The Company will at any time during the said term grant to any person firm or Company nominated by the Syndicate for the purpose and approved by the Company (such approval not to be unreasonably withheld) full license and liberty to use the said processes in the United States of America and in the Dominion of Canada but not elsewhere in the treatment of ores obtained from properties to be specified in the said License upon such terms as may from time to time be mutually agreed between the Company and the Syndicate but the Syndicate shall not be entitled to assign the

license hereby granted or any of its benefits hereunder or to grant sub-licenses without the consent of the Company first obtained and any consideration payable to the Syndicate under any license to be granted under this Clause shall be carried into the account referred to in Clause 5 hereof and be reckoned in such account in ascertaining the half share of net profit payable to the Company as provided in such clause and every license shall enure for the benefit of the Company after the expiration of the said term of two years or after the determination of the license hereby granted before the expiration of such term. Any royalty or other consideration payable to or receivable by the Company under any license to be granted under this Clause shall belong and be divisible and payable to the same persons and in the same manner as is provided in Clause 1 hereof with reference to royalties or other considerations payable or arising under compulsory licenses.

3. Part of the consideration for the exclusive license and the other rights and interests hereby granted to the Syndicate by the Company shall be the sum of Seven hundred and fifty pounds which shall be satisfied by the allotment forthwith to the Company or its nominees of Fifteen thousand fully paid "B" shares in the capital of the Syndicate of One shilling each.

4. As further part of the said consideration for the said License the Company shall be entitled to a further One thousand seven hundred and fifty pounds to be

paid and satisfied from time to time by the allotment to the Company or its nominees of one fully paid "B" share for every "A" share that may be subscribed for from time to time in addition to the Fifteen thousand "A" shares which are to be subscribed for forthwith the intention being that when the Fifty thousand "A" shares are subscribed for the Company shall be entitled to the Fifty thousand "B" shares of One shilling each fully paid.

5. As the residue of the consideration for the said License the Syndicate agree that during the said term of two years the Syndicate will use their best endeavor to apply and turn to profitable account in the United States of America and in the Dominion of Canada the processes and inventions covered by the said patents and in particular to secure and deal with in terms of the Memorandum of Association of the Syndicate options (calculated to yield profit) upon mines ores dumps tailings slimes and other suitable mining products and to secure users of the said processes on license for royalties or on profit sharing basis or otherwise and that the Syndicate will keep proper books of account and make proper and sufficient entries therein of all business and all receipts and property of the Syndicate and in particular of all matters and transactions relating and incident to the application and working of the said processes and inventions or any of them under this Agreement and the payment of royalties and other con-

siderations to the Syndicate and that all such books of account and all documents relating to the business of the Syndicate shall at all times be open to inspection and examination by the Directors of the Company and their representatives who shall be entitled to make such copies and extracts thereof and therefrom as the said Directors and their representatives shall from time to time require and that the Syndicate will at least once during every calendar month of the said term of two years furnish and send to the Company a written report containing particulars of all mines mineral products options and properties to which any of the said processes may be applied or which may be acquired or disposed of by the Syndicate whether any of the said processes shall be applied thereto or not and the results of the Syndicate's operations with regard thereto and that the Syndicate will within thirty days after every tenth day of April and tenth day of October during the said term of two years send to the registered Office of the Company a full and detailed account of the business carried on and royalties and other considerations and moneys received by the Syndicate and outgoings and expenses incurred by the Syndicate during the half years respectively ending on the dates before mentioned and showing the net profit earned by the Syndicate for such half year and that the Syndicate will at the same time pay to the Company one half of the net profit earned by the Syndicate during each such half year as royalty and additional consideration for the granting of

the License hereby granted PROVIDED that the Company shall give credit to the Syndicate on receipt of the said half of the net profit for all sums receivable by the Company by way of dividend on the said "B" shares held by the Company the intention of these presents being that the Company shall receive one half of all net profits made by the Company from whatsoever source and that if the Syndicate shall duly pay the said half of the net profit the Company shall pay to the Syndicate or allow to them in account all sums receivable by the Company by way of dividend on the said "B" shares as aforesaid in respect of the period for which the said half of the net profit has been paid AND FURTHER that if the Syndicate shall not purchase the said Patents under Clause 13 hereof or if this license shall be determined before the expiration of the said term of two years the Syndicate shall at the end of the said term or on the earlier determination of this license deliver to the Company all the Syndicate's books of account and all documents belonging to it in any way relating to the said processes and inventions including all deeds or agreement of license in the Syndicate's possession and that all such books and documents shall thereupon become the absolute property of the Company.

6. AND IT IS HEREBY MUTUALLY AGREED that in case any question or dispute shall arise between the parties hereto as to the amount of the profits from time to time earned by the Syndicate or as to any mat-

ter of account between the parties hereto such question or dispute shall be determined by the Auditors for the time being of the Company whose Certificate in writing relating thereto shall be conclusive and binding upon both parties.

7. The Syndicate shall not without the written consent of the Company during the said term of two years or at any time thereafter directly or indirectly use or employ or be in any way party or privy to the using or dealing with any process or processes for the concentration of ores by flotation methods of separation of products of concentration from one another belonging to or held or worked by any other Company Corporation Syndicate or person but shall exclusively use deal and be interested in the process or processes patents and inventions of the Company.

8. The Syndicate shall not at any time during the said term of two years or at any time thereafter and whether the license hereby granted shall be determined before the expiration of such two years or not dispute the validity of any of the patents or patent rights belonging to the Company nor in any manner support any litigation against the Company nor shall the new Company hereinafter mentioned at any time hereafter dispute such validity or in any manner support any such litigation as aforesaid.

9. The Syndicate hereby agrees with the Company

that the Syndicate and the new Company mentioned in Clause 13 hereof will so long as the term~~s~~ of any of the said scheduled patents or of any patent in the United States of America or the Dominion of Canada for any improvement thereon or addition thereto belonging to the Company or the Syndicate shall continue forthwith from time to time communicate to the Company and transfer to it the sole and exclusive benefit of any improvement in or addition to the said inventions or processes or any discovery mechanical or otherwise useful in connection therewith which the Syndicate or the new Company or their respective servants agents and workmen may make devise or discover during the continuance of this Agreement and will give to the Company full information as to the exact mode of working and using the same and will from time to time at the request and expense of the Company but without making any charge therefor execute and do all such documents and things as may be requisite for the purpose of enabling the Company in its own name to obtain patents or protection for such improvements or discoveries in this or any foreign Country and will from time to time during the continuance of this Agreement gratuitously give all such advice explanation and instruction to the offices and workmen of the Company as may be necessary to enable them effect~~ively~~ually to exercise work and utilize such improvements and discoveries as aforesaid but any such patent granted to or vested in the Company in respect of the United

States of America and the Dominion of Canada shall be subject to the license hereby granted in the same manner in all respects as the Patents mentioned in the Schedule hereto.

10. The Company will during the continuance of this Agreement at the request and expense of the Syndicate give to the Syndicate all such technical advice and assistance as they may reasonably require in connection with all of the said processes of the Company and the methods of working the same.

11. If at any time or times hereafter during the said term of two years so long as the license hereby granted shall subsist or (in case the Syndicate shall exercise the said option to purchase) at any time during the terms of any of the said Patents the Company shall acquire or otherwise become possessed of or interested in any improvement or improvements upon the inventions the subject matter of the existing Letters Patent or the mode of using or applying the said processes then and in every such case the Company shall forthwith communicate such improvement or improvements to the Syndicate and give to the Syndicate or its duly appointed officer or officers full and sufficient information instructions and assistance respecting the mode of working and using any such improvement or improvements and the Syndicate shall be entitled (so far as the Company shall be legally competent to confer such right) to use and exercise the same in the United

States of America and in the Dominion of Canada but not elsewhere without any further payment or compensation except actual and pocket expenses to the Company in respect thereof and if the Company shall be entitled to confer the right to do so and the Syndicate shall duly exercise its said option to purchase the said Scheduled patents the Syndicate shall be entitled to Letters Patent for the United States of America and the Dominion of Canada but not elsewhere in respect of such improvements and the Company will at the cost of the Syndicate or its assigns cause to be done all such acts and things as may be necessary for obtaining such Letters Patent as the Company shall be entitled thereto and for vesting the same in the new Company hereinafter mentioned.

12. The Syndicate shall during the said term of two years pay all necessary fees for keeping the said patents and patent rights in force and if during such term any infringement of any of the said Letters Patent shall come to the knowledge of either party hereto such party shall forthwith give notice of such infringement to the other but it shall not be obligatory on either party to take proceeding to restrain or recover damages in respect of such infringement or otherwise for defending or upholding any such patents.

13. For the considerations before mentioned the Syndicate shall be entitled at any time during the said term of two years unless the license hereby granted

Complainants' Exhibit—License Agreement.

shall have been previously determined to purchase all the said Patents of the United States of America and Dominion of Canada and the Company if the Syndicate's option shall be duly exercised will sell such patents accordingly upon the conditions following:

(a) The consideration for such sale shall be a sum payable in fully paid One pound shares of a New Company to be registered by the Syndicate in England to acquire the said Patents equal to one half of the total registered nominal capital of such new Company which shall be accepted in substitution for all the Company's rights in respect of "B" shares in the Syndicate of One shilling each then held by them or their nominees except the right to participate in surplus assets on any distribution in a winding up of the Syndicate.

(b) The total nominal capital of the said new Company shall be not less than two hundred thousand pounds and such capital shall be divided into shares of One pound each and at least one fourth of the total nominal capital of such new Company shall on or before completion of the sale be allotted to responsible persons on subscriptions for payment in full of cash free of all deduction in respect of underwriting commission or other charges or expense of any kind.

(c) At least one half of the first Directors of

Complainants' Exhibit—License Agreement.

the New Company shall be nominated by the Company (party hereto) and the Memorandum and Articles of Association of the new Company shall be in such form and shall contain only such clauses as shall be approved by the Company (party hereto) and in the case of any difference or dispute arising between the parties hereto respecting the terms of such Memorandum and Articles such difference or dispute shall be determined by reference to arbitration under clause 16 hereof.

(d) The Syndicate shall send to the Company's registered address at least three calendar months' notice in writing of their intention to exercise the option to purchase such notice to expire on or before the end of the said term of two years.

(e) Upon completion of the said sale the said patents or such of them as shall then subsist and such right to improvements as the Syndicate may be entitled to under this Agreement shall be duly assigned or vested in the said new Company and the new Company shall in such Assignment enter into a covenant with the Company (party hereto) to carry out the obligations of clauses 8 and 9 hereof so far as such obligations are to be observed by the new Company.

(f) In case when the notice shall be given by the Syndicate under sub-clause (d) of this ~~pur-~~

P. 970, L. 28, Insert " clause or thereafter prior to comple-tion of the pur-" after " this "

Complainants' Exhibit—License Agreement.

chase any legal proceedings shall be pending relating to the validity of any Letters Patent of the United States or the Dominion of Canada for the time being subject to this Agreement or to any alleged infringement of any such Letters Patent in which proceedings the Company shall be a party as Plaintiff Defendant Petitioner or otherwise the Syndicate shall procure the new Company on or before completion of the purchase to pay to the Company (party hereto) all costs and expenses which the last named Company may have incurred or for which it may be liable and to enter into a sufficient covenant to pay and discharge and indemnify the Company (party hereto) against all costs and expenses which may thereafter be incurred or which the Company (party hereto) may become liable to pay in or in respect of any such proceeding.

g
(~~f~~) The said sale shall be made subject to any license which may be granted under clause 2 hereof but the new Company shall after the said sale be entitled to the royalties or other consideration payable under any such license.

(h) Unless the said purchase shall be completed upon the conditions hereinbefore mentioned and on or before the expiration of the said term of two years the said option shall cease and all the agreements and obligations on the part of the Company

under this Agreement shall be at an end and for the purposes of this clause time shall be deemed to be of the essence of the Contract.

14. If the option to purchase contained in clause 13 hereof shall not be exercised or if such purchase shall not be duly completed then or if the said license should be determined before the end of the said term of two years all improvements on or additions to any of the said processess or inventions which may have been discovered or acquired by the Syndicate and all letters patent which may have been granted or applied for on behalf of the Syndicate and the full right to apply for Letters Patent in respect of such additions and improvements in all Countries where such right may subsist shall become the absolute property of the Company and the Syndicate shall execute all such assurances as may be necessary to vest the rights to such additions and patents in the Company and in any such case the Company shall have the right and option to take over from the Syndicate all or any options and or rights for working mineral products belonging to the Syndicate and the benefit of all contracts which may have entered into by the Syndicate for such purpose and all or any mines, ores and other mineral products which may have been acquired by the Syndicate at the price paid by the Syndicate to the Vendors or Grantors thereof respectively such option to be exercised as to all or any exclusively of the other of such options

Complainants' Exhibit—License Agreement.

rights contracts mines ores and other mineral products by notice in writing to be given by the Company to the Syndicate within six calendar months after the expiration of the said term of two years or after the determination of the license hereby granted as the case may be. Provided that if at the end of the said term of two years or at the end of the further term of one year (in case the said option shall be extended under clause 17 hereof) the Syndicate shall be engaged in applying or using any of the inventions process apparatus plant or machinery described in the specifications of any of the said letters patent to or on any specific property or properties in the United States or in Canada and if the Syndicate shall not exercise the option or right to purchase the said American and Canadian letters patent under the provision in that behalf hereinbefore contained then the Company will if requested by the Syndicate so to do grant the Syndicate a license to continue such application and user of the said inventions processes apparatus plant or machinery at or on the said specific property or properties but not elsewhere so long as the said letters patent or any of them shall be kept on foot and such application and user be continued by the Syndicate and such license shall be subject in all respects to the provisions and agreements hereinbefore contained which are applicable during the term of two years from the date hereof so far as such provisions can apply to such specific property or properties except clauses 3 and 4

of this agreement and except that such license shall provide in variation of the terms of clause 12 of this Agreement that during the continuance of the said license the Company and not the Syndicate shall pay all fees necessary for keeping the said patents and patent rights in force and subject as hereinafter appears but including the agreement for the payment to the Company by the Syndicate of one half the net profits of the Syndicate by ~~the~~ way of Royalty and so that such expression "net profits" and its application to the terms of the license so to be granted shall be deemed to mean the Syndicate's entire net profits and not only the net profits attributable to such specific property or properties as aforesaid and such license shall also contain a covenant by the Syndicate that if after all the said letters patent shall have expired or shall have ceased to be kept on foot the Syndicate shall continue the application and user of the said inventions processes apparatus plant or machinery at or upon any property to which the said license shall apply the Syndicate will continue to pay to the Company one half of its net profits as hereinbefore defined so long as such application and user shall be so continued by the Syndicate and also a covenant by the Syndicate that the Syndicate before discontinuing such user and application on or to any property included in such license will give to the Company six calendar months previous notice of its intention to discontinue the same and that until the expiration of such six calendar months notice the Syndicate

Complainants' Exhibit—License Agreement.

shall remain liable to pay to the Company one half of its net profits as aforesaid earned up to the end of such six calendar months whether such user and application shall or shall not have ceased prior to the expiration of such notice Provided that the Syndicate shall not after the end of the said option period of two or three years be entitled to require the Company to grant licenses under clause 2 hereof and that nothing in this clause shall a~~e~~ffect the right of the Company after such option period to retain any consideration paid for a license granted under that clause Provided that the license to be granted with regard to the said specific property or properties shall be a non-exclusive license and shall not prejudice or affect the right of the Company to work any of the said inventions and processes themselves or to grant other licenses to use and work the same Provided also that no such license as aforesaid shall renew or extend the option to purchase under clause 13 hereof Provided also that any specific property or properties as to which any such license as aforesaid may be granted under this clause shall be deemed to be excluded from the option contained in clause 14 hereof so long as the Syndicate shall continue to apply or use the said processes and inventions or any of them to or on the said property or properties and the Company shall have the right to purchase any such property or properties under such clause within six months after the exiration of the notice of the cessor of such application or user as hereinbefore provided.

15. Provided always that if "A" shares of the Syn-

dicate to the nominal value of Fifteen thousand pounds shall not within six months from the date hereof be allotted to responsible persons on subscriptions for payment wholly in cash or if the Syndicate shall make default for the period of at least sixty days in paying to the Company the amount of any sum certified by the Company's Auditor to be due to the Company on account of the profits of the Syndicate or if an effective resolution shall be passed or a compulsory order shall be made for the winding up of the Syndicate or if the Syndicate shall commit any breach or default of any of the agreements on its part herein contained or in the case of a breach capable of being made good shall within thirty days after it has been served by the Company with notice to do so neglect or refuse to do so then the Company at any time thereafter and notwithstanding any merely implied waiver by it of its rights to do so may by serving the Syndicate or leaving at its registered office a notice in writing for this purpose forthwith revoke and cancel the license and option hereinbefore granted and thereupon the said license and option shall be determined and the Company shall be freed from all obligations and agreements on its part herein contained or arising hereunder but without prejudice to any claim which the Company might have against the Syndicate for its share under this agreement of any of the profits of the Syndicate and which in such case shall be payable by the Syndicate apportioned up to the date of the revocation of the said license.

Complainants' Exhibit—License Agreement.

16. Subject as is hereinbefore provided with respect to matters which under clause 6 hereof shall be determined by the Certificate of the Company's Auditors it is hereby agreed that if and so often as any dispute difference or question shall arise between the Company and the Syndicate as to the meaning or construction or the effect incidence or consequence of this agreement or any part thereof or any article or clause herein contained or otherwise relating to the premises every such dispute difference or question shall be referred to Arbitration in England pursuant to the Arbitration Act 1889 or any statutory modification or reenactment thereof for the time being in force.

17. In the event of the Syndicate being desirous of having an extension of the option hereby granted and of such desire shall give to the Company notice in writing not less than three months prior to the expiration by effluxion of time of the license granted by clause 1 hereof then the Company will on the Syndicate paying to the Company the further sum of Five thousand pounds in cash extend the license and option hereby given for a further period of one year and in such case this Agreement shall be read and construed as if the license granted under clause 1 hereof had originally been granted for three years instead of two.

AS WITNESS the respective Common Seals of the Companies parties hereto.

Complainants' Exhibit—License Agreement.

THE SCHEDULE HEREINBEFORE REFERRED TO
UNITED STATES OF AMERICA.

No.	Date of Patent.	Name of Applicant.	Description.	Known as
777,273	13.12.04	A. E. Cattermole	Separation of the metallic constituents of ores from gangue	Separator
763,259	21. 6.04	A. E. Cattermole	Classification of the metallic constituents of ores	Classifier
763,260	21. 6.04	A. E. Cattermole	Separation of the metallic constituents of ores from gangue	Separator
793,808	4. 7.05	Sulman & Picard	Ore Concentration	Bubbles
788,247	25. 4.05	Cattermole, Sulman & Picard	Ore Concentration	Soap and Flotation
777,274	13.12.04	Cattermole, Sulman & Picard	Concentration of Minerals from Ores	Soap and Granulation
879,985	25. 2.08	H. L. Sulman	Separation of Metalliferous minerals from gangue	Table Flotation
835,120	6.11.06	Sulman, Picard & Ballot	Ore Concentration	Oleic Acid Froth
835,143	6.11.06	H. L. Sulman	Ore Concentration	Boiling
835,479	6.11.06	Sulman, Picard & Ballot	Ore Concentration	Superaerator
902,018	27.10.08	H. L. & E. A. Sulman	Ore Concentration	Buddle
955,012	12. 4.10	H. L. Sulman	Concentration of Ores	Alcohol
962,678	26. 6.10	Sulman, Greenway & Higgins	Ore Concentration	Solution
953,746	5. 4.10	T. J. Hoover	Apparatus for Ore Concentration	Froth Apparatus with baffle
Despatched	6. 7.10	T. J. Hoover		Froth apparatus agitato as pump

Complainants' Exhibit—License Agreement.

DOMINION OF CANADA.

No.	Date of Patent.	Name of Applicant.	Description.	Known as
7,785	14. 6.04	A. E. Cattermole	Improvements in the separation of the Metallic Constituents of ores from gangue	Separator
7,786	14. 6.04	A. E. Cattermole	Improvements in the classification of the metallic constituents of ores	Classifier
7,700	7. 6.04	Sulman & Picard	Improvements in or relating to ore concentration	Bubbles
94,516	1. 8.05	Cattermole, Sulman & Picard	Improvements in or relating to concentration of minerals from ores	Soap
96,183	21.11.05	Sulman, Picard & Ballot	Improvements in or relating to ore concentration	Air Flotation combined
96,182	21.11.05	Sulman, Picard & Ballot	Improvements in or relating to ore concentration	Oleic Acid Froth
94,332	25. 7.05	Sutton, Steele & Steele	Electrical process of separating the particles of a mass of the components of a mixture or of material in solid (pulverized) liquid or gaseous form	Di-electric Separator
94,718	15. 8.05	Sutton, Steele & Steele	Dry concentrating table and particularly to a construction by which a riffled table is adapted for use in dry concentration by the use of air as a floating medium for the material	Dry Concentrating Table
99,743	26. 6.06	Sulman, Picard & Ballot	Improvements in or relating to ore concentration	Superaerator
Ser. No. 152162 Despatched 29.1.10		T. J. Hoover		Froth apparatus with baffle

(Seal of Minerals Separation Limited)

THE COMMON SEAL of Minerals Separation Limited was hereto affixed in the presence of
S. GREGORY,
W. W. WEBSTER, Directors
A. O. WILLIAMS, Secretary.

(Seal of Minerals Separation American Syndicate Limited)

THE COMMON SEAL of Minerals Separation American Syndicate, Limited, was hereto affixed in the presence of
JOHN BALLOT,
FRANCIS L. GIBBS, Directors.
A. O. WILLIAMS, Secretary.

Complainants' Exhibit—License Agreement.

Kingdom of Great Britain and Ireland, } ss.:
City of London, England, }

Before me personally appeared SETH GREGORY and WALTER WILLIAMS WEBSTER, to me personally known, who being by me duly and severally sworn, did each depose and say that he is and was on October 10, 1910, a director of MINERALS SEPARATION, LIMITED, one of the corporations described in and which executed the above instrument, and that ALBERT OWEN WILLIAMS, is and was on October 10, 1910, the Secretary thereof, and did further each depose and say that he knew the seal of the said corporation; that the seal affixed to said instrument was such corporate seal; that it was so affixed by order of the Board of Directors of the said corporation on October 10, 1910, and that he then signed his name thereto by like order; and the said SETH GREGORY and WALTER WILLIAMS WEBSTER acknowledged the said instrument to be the free act and deed of the said corporation.

Witness my hand and official seal at London, England, this Eighth day of January, A. D., 1912.

(Seal of U. S. Consulate)

RICHARD WESTACOTT,
Vice and Deputy Consul-General of the United States of America, London, England

(American Consular Service Fee Stamp $2.00.)

P. 981, L. 13, Insert " he knew the seal of the said corporation ; that " before " The "

Complainants' Exhibit—License Agreement.

Kingdom of Great Britain and Ireland, } ss.:
City of London, England. }

Before me personally appeared JOHN BALLOT and FRANCIS LOMAX GIBBS, to me personally kohwn, who being by me duly severally sworn, did each depose and say that he is and was on October 10, 1910, a director of MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, one of the corporations described in and which executed the above instrument and that ALBERT OWEN WILLIAMS is and was on October 10, 1910, the Secretary thereof; and did further each depose and say that the seal affixed to said instrument was such corporate seal; that it was so affixed by order of the Board of Directors of the said corporation on October 10, 1910, and that he signed his name thereto by like order; and the said JOHN BALLOT and FRANCIS LOMAX GIBBS acknowledged the said instrument to be the free act and deed of the said corporation.

Witness my hand and official seal at London, England, this Eighth of January, A. D., 1912.

(Seal of U. S. Consulate)

RICHARD WESTACOTT
Vice and Deputy Consul-General of the United States of America, London, England

(Consulate General American Consular Service Fee Stamp $2.00.)

Complainants' Exhibit Stipulation.

UNITED STATES DISTRICT COURT,

DISTRICT OF MONTANA.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED,
Complainants,
vs.
JAMES M. HYDE,
Defendant.

In Equity.

IT IS HEREBY STIPULATED that, pursuant to Clause 17 of the agreement between Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, complainants herein (such license agreement being in evidence as "Complainants' Exhibit, License Agreement") the license and option to Minerals Separation American Syndicate, Limited, under the patents referred to in the schedule annexed to said agreement, including the patent in suit, have been extended for a further period of one year from October 10, 1912, and that this stipulation shall have full force and effect as evidence of that fact.

New York, N. Y., Dec. 2, 1912.

HENRY D. WILLIAMS,
Counsel for Complainants.

SHERIDAN, WILKINSON, SCOTT & RICHMOND,
Counsel for Defendant.

Chicago, Ill., Nov. 29, 1912.

Complainants' Exhibit Abstract of Title.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the Digest of this Office of all Assignments, Agreements, Licenses, Powers of Attorney, and other instruments of writing, found of record up to and including September 18, 1911, that may affect LETTERS PATENT granted to

Henry L. Sulman, Hugh F. Kirkpatrick-Picard, and John Ballot, London, England.

Patent No. 835,120. Dated November 6, 1906. "Ore Concentration."

Searched from August 23, 1902.

(Patent Office Seal.)

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this twenty-ninth day of September, in the year of our Lord one thousand nine hundred and eleven and of the Independence of the United States of America the one hundred and thirty-sixth.

F. H. TENNANT,

Assistant Commissioner of Patents.

Henry L. Sulman,
Hugh F. Kirkpatrick-Picard
and
John Ballot. 1.

Complainants' Exhibit—Chapman Report August 16, 1907.

Instrument dated Dec. 7, 1909. *Recorded Aug.* 28, 1911.
Liber Y. 87, *page* 80.

Parties.	*Invention.*
Henry Livingstone Sulman	Ore Concentration.
H. F. K. Picard	Nov. 6, 1906, 835,120.
John Ballot	
to	
Minerals Separation, Limited,	
62 London Wall,	
London, England.	

These Assignors, stating that they own said letters patent, and all rights thereunder, assign the whole right, title and interest in said invention and letters patent. Consideration $1.—

Complainants' Exhibit, Chapman Report, August 16, 19~~1~~07.

THE SULPHIDE CORPORATION LIMITED

Central Mine,
Broken Hill, N. S. W.
August 16th, 1907

Theodore J. Hoover,
Manager Minerals Separation Ltd.,
London.

Dear Sir,

ZINC CORPORATION Ltd.

On Mr. Courtney's last visit to Broken Hill he in-

Complainants' Exhibit—Chapman Report August 16, 1907.

structed me to report briefly on the working of the Granulation Process on the British Mine.

Mr. Huntley's Regime—dating back to the time when Mr. Huntley was superintendent of the Zinc Corporation's Broken Hill Works, I was taken over the Potter Process Plant erected under Mr. Queneau's instructions and according to his ideas. Mr. Huntley was very anxious to try this plant with a little oil added to the agitation without addition to the plant. I did not give much encouragement to this proposal and finally, Mr. Huntley arranged for a nest of agitators of our box type, together with spitz box separators of our pattern. Work was then started with very encouraging results.

The plant was very weak in its feeding and crushing stages, and I constantly advised that attention to the crushing department was quite as important as to the treatment section. Some attention was being paid to this until instructions were given that the plant was to be run to test tonnages and grade of concentrates. The feed to plant was therefore rushed and was exceedingly irregular, but high grade concentrates were recovered.

The increase of tonnage determined the weak points of the plant after several weeks of annoying petty stops due to bad methods of elevation and insufficient boiler plant.

Complainants' Exhibit—Chapman Report August 16, 1907.

OPERATIONS UNDER MR. MITCHELL'S SUPERVISION.

It was at this time that Mr. Mitchell assumed charge of operations and various changes of the staff occurred. Again I emphasised the importance of crushing with regular feed of both grainy material and slimes produced from crushing. I was told that the plant was merely an experimental one, and it was to be run only for tonnage and grade of recovered concentrates. The management were aiming at 500 tons per day and a 46% Zn.

HIGH TONNAGES.—This mad desire for tonnage irrespective of recovery became the object of foremen and shift bosses, and nothing was left undone to produce good tonnages. The breakages to plant caused delays of 8 to 12 hours per day (average), so that when plant was running it was rushed to such an extent that it was hardly worth while putting the crude tailings through the crush~~er~~ing section.

TREATMENT WITHOUT CRUSHING AND IRREGULAR FEED.

Besides the feed from crusher section, an incline tramway and conveyor belt delivered current British Mill Wilfley and Card table tailings together with old dump slimes to the treatment section. As regards size this feed was quite amenable to treatment, but here the worst irregularities of the feed occurred. As trucks came up the inclined tram they were tipped into a hop-

per directly over the inclined belt. This feed to plant would last a few minutes only, and while the trucks were being returned and loaded, no feed from this source was delivered to the treatment section. I estimate that the belt was delivering feed for treatment 20% of its time, and the remainder of the time no feed was going to the agitators from this source. There is no need to state how difficult it was to regulate the acid and oil feeds to ensure successful work.

This was partially remedied by the introduction of one 5 ft. agitator which delivered its agitated pulp to the mixers for treatment.

At the time when the matter of tonnages was obviously very critical (the reason not being disclosed) shift bosses on several occasions had current British Mill jig tailings (uncrushed) tipped as Card and Wilfley tailings. As this was going on unchecked I called the attention of the officials to this underhand method of getting high tonnages. They promised to have it stopped, but this abuse continued. I, therefore, reported the matter to Mr. Mitchell, who promised that it should be stopped, but on making other visits to the plant I saw that it continued, with or without the superintendent's knowledge. I would add that the tailings from the jigs at British Mill are a product of 3 m/m. crushing and assay from 12% to 14% Zn.

Slimes from Crushing.—The regular feed of slimes produced from crushing along with the grainy material was a matter that I claimed had to be seen

to early. No definite line of work, however, was agreed upon, but the management were getting interested in this proposition when the plant shut down.

Size of Feed.—This should have been reduced to ½ m/m. and below, whereas sizing tests made gave 33% of the total feed over ½ m/m. This oversize often reached 50% of the feed, and was composed of jig tails from the dump, and jig tails direct from British Mill, the tails from the Card and Wilfley tables that were treated being of a sufficient fineness not to require further crushing.

Results.—In spite of these adverse conditions, a very high grade zinc product was being produced and shipped, and satisfaction was expressed by those in charge.

When the 500 tons per day limit had been reached and the plant was running smoothly, I again suggested that more attention be paid to crushing to ensure higher recoveries. Mr. Mitchell then expressed the opinion that finer crushing would not give better results, and, no doubt, reported the same to his Board.

I was certain that this was the remedy of the trouble, and was glad to know that the plant was to be given over to work on our own crushing lines for a definite period.

As you know, when negotiations were being made the plant was shut down without notice.

Yours faithfully,

GEO. A. CHAPMAN.

Complainants' Exhibit, Higgins Report, January 4, 1911.

2, King John's Court, E. C.
4th Jan., 1911.

Messrs. Minerals Separation Limited,
62, London Wall, E. C.

Dear Sirs,

RE "TECOLOTES SLIME TAILS"

The tests made on this ore show that it is amenable to treatment although low in metallic values; for this reason a high recovery cannot be expected. The grade of the concentrates in zinc is good, especially in test No. 220 where no acid was used. The limit of the zinc assay in the concentrates calculated from the figures given is 44.5%. In my opinion the bulk of the insolubles in the concs. resulted from the 2nd & 3rd treatments where only small bulks were obtained, so that by eliminating these a higher grade concentrate should be obtained with a slightly lower recovery, unless the 2nd & 3rd concs. were retreated.

It is noteworthy that the grade of the concentrates obtained by the use of Turpentine (Russian) is almost as good as that from the use of oleic acid with 90 lbs. of sulphuric acid, further, that Turpentine in cold circuit (12°C) was almost useless, which may have been due to the oxidation in drying the sample before it was sent to you.

I am, dear Sirs,

Yours faithfully,

A. HOWARD HIGGINS.

6. enclos.

Complainants' Exhibit Hyde Letter February 7th, 1911.

No. 1, London Wall Buildings,
London E. C.
7th February, 1911.

Mr. A. C. Howard,
City

Dear Sir,

Since requesting you to prepare a note for me on the subject of making working tests with the frothing equipment, I have decided not to continue with Minerals Separation, and shall not need the information asked for.

I hope you have not been to any trouble in preparing it.

I shall remain in London in consultation work with several companies for two or three months.

Thanking you for the courtesies shown me, I remain,

Sincerely yours,
JAMES M. HYDE.

Complainants' Exhibit Froment Description.

Description et instructions
pour la concentration
des minerais.

A. DESCRIPTION

Le materiel se compose:

1° d'un malaxeur centrifuge

2° d'une cuve à serpentin

3° d'un crible d'épuration hydraulique avec extracteurs (si cela est necessarie)

4° d'une caisse à filtre

Complainants' Exhibit—Froment Description.

La légende qui accompagne le déssin donne déjà une idée assez complète du matériel, il en est de même du matériel d'essai.

Néammoins, nous donneront quelques reinseguements supplémentaires.

A. Le malaxeur centrifuge se compose d'un corps cylindrique en tôle forte rivée avec boulons, et dans laquelle deux agitateurs marchent en sens inverse à raison de 300 tours environ par minute.

Le minerai est versé on arrivé par la petite auge située sur le coté, et l'huile est ajoutée par un petit tube situé à coté.

(Observations). Le malaxeur d'éssai peut traiter environ 2 Kil. ½ de minerai par charge. On doit faire tourner les agitateurs au fur et à mesure que l' on verse le minerai avec l'eau et le calcaire.

Pour 2 Kil. ½ de minerai il faut environ 6 litres d'eau. Tourner pendant quelques minutes, pius évacuer le minerai en tournant toujours.

B. La cuve à serpentin peut être construite en bois. Il en faut deux par malaxeur pour alterner les charges. Pendant que l' une est en travail, l'autre se remplit. Chaque cuve doit contenir environ de 200 à 400 Kilos de minerai. Cela est affaire de pratique. La hauteur est d' environ 0m. 50 sur un diamètre de 1 m. 70 suivant la densité du minerai à traiter.

Un serpentin en plomb occupe le fond de la cuve. Ce serpentin est troué, les trous sont en dessons pour éviter qu'ils ne se bouchent pas. Le tube remontant du serpentin se divise en deux branches, l'une destinée a recevoir la portion d'acide sulfurique nécessaire; l'autre, pouvant, si cela est nécessaire, etre reliée à un générateur de vapeur. La vapeur, sous faible pression, arrive par les trous du serpentin et active les réactions.

Cela est seulement nécessaire dans les pays froids. Dans le cas où cette branche ne sert pas à la venue de la vapeur, elle peut, avec avantage, remplacer le tube à eau

dont il va être parle. (Dans le matériel d'essai cette chandiére a été laissée.

Un tube à eau sans pression, mais avec robinet, doit venie déboucher, à 0 m. 45 du fond, de facon a permettre l'evacuation des sulfures qui montent à la surface. Ce tube est inutile si l' on vent écumer ces sulfures où les pousser vers l' auge d' évacuation. Il peut être remplâcé par une des deux branches du serpentin.

Un rateau horizontal tourne lentement dans la cuve, il set um par un arbre vertical et une poulie; il doit faire 10 à 12 tours par minute.

C. Le crible d'èpuration est constitué par un cadre en bois dur, sous lequel est fixée une plaque d'aluminium percée de trous de ½ millimètre. Ce cadre est soutenu par des montants en bois auxquels il est fixé par des attaches à ecrou de façon à obtenir l'inclinaison nécessaire.

Les montants sont fixés à une cuve en bois dont la longueur est d'environ 2 M. 50, la largeur 0 m. 75. Le crible proprement dit en occupe presque toute la surface.

Le mouvement est donné par un éxcentrique mais il est nécessaire d'observer que les secousses doivent être nombreuses avec peu d'amplitude, autrement le crible fonctionnera mal.

La caisse est percée de 3 trous pour l'évacuation des résidus et ces trous correspondent à 3 divisions de la caisse. Un tube supérieur de décharge déverse les parties légères dans la caisse à filtre.

Le déssin montre 3 extracteurs pointus pour une extraction continue. Mais, dans ce cas, il faut beaucoup d' eau. Un tube à eau, sans pression, mais avec robinet, entre vers le milieu de la caisse du crible amenant doucement l'eau necessaire pour tenir toujours le crible sous l'eau.

D. La caisse à filtre est faite en bois, elle a les dimensions que l'on vent bien lui donner; il n'y a pas, à cet égard, des mésures précises. Elle est garnies de filtres doubles en toile avec poussier de charbon. Au travers de ces filtres l'eau s'écoule et les sulfures sont retenus.

Complainants' Exhibit—Froment Description.

B. INSTRUCTIONS.

L'expérience a prouvé que pour arriver à la parfaite désintégration des particules constituantes du minerai sans pour cela faire de l'impalpable, le broyage doit se faire en deus fois. Le première fois, le minerai broyé doit passer à travert d'un tamis No. 15, soit dans un moulin à boules, soit dans un moulin Griffin on autre. La seconde fois il doit passer dans un tamis 120 environ et le broyage sera fait par un moulin Huttington, boccard, etc.

La production est beaucoup plus grande par voie séche que par voie humide, mais il ya a plus d'impalpables. A sa sortie du second moulin, le minerai sera donc soumis à 2 on 3 spitzkasten pour éliminer la portion de schlammes trop fins pour être traités et qu' aucune méthode n' a pu traiter jusqu' ici. Dans l'état de grosseur où il doit se trouver, le minerai arrive avec un peu d'eau dans le malaxeur centrifuge toujours en mouvement. Lorsque l'on juge que la quantité de minerai est suffisante (environ 2 à 300 kilos) pour constituer une charge, on ajoute 1% environ de carbonate de chaux, 2% au maximum dans les cas difficiles, et environ 1 à 1½% de huile minérale à machine. On laisse le malaxeur agir pendant 10 minutes environ, l'essentiel est que tous les grains de sulfures soient bien touchés par 1 huile.

(Observation) Si la teneur du minerai dépasse 5% de matières métalliqus, cuivre, plomb, il faudra ajouter un peu plus d' huile En thèse générale on peut compter;

1%	huile pour	jusqu' à	5%	de métaux
1½%	"	"	10%	"
2%	"	"	15%	"

Il est rare que l'on ait à enrichir des minerais contenant plus de 15% de cuivre. Dans nos contrées: Italie, France, Espagne, un minerai à 15% de métal cuivre est considéré comme riche et traité tel quel. Pour les minerais de plomb, in enrichit jusqu' à 60% de plomb, il est rare que l'on aille au Dela.

En conséquence, pour un minerai plombeux d'une teneur de 20% il faudra 2% huile

2°	Pour une teneur de		30%......	2½%	huile
3°	"	"	40%......	3%	"
4°	"	"	50%......	3½%	" etc.

Il est logique de penser que le carbonate de chaux suit à peu près une même proportion puisqu' il faudra davantage de gaz pour un minerai riche que pour un minerai pauvre. La dépense est donc proportionnelle à la richesse du minerai et par conséquent proportionnelle à la teneur du concentré obtenu. Le procédé en question trouve mieux son application dans le traitement des minerais pauvres que dans ceux des minerais riches. Il serait parfait, par éxemple, pour reprendre et traiter les stériles et les ½ mixtes, résidus des laveries ordinaires, surtout lorsque ces laveries ont en à traiter des minerais difficiles. Quoiqu' il en soit, après le malaxage centrifuge, le minerai est déversé, le malaxeur étant toujours en mouvement dans la cuve à serpentin.

Pendant que le malaxaur s'éxonère de sa charge de minerais dans la cuve, l'agitateur dont celle-ci est munie est mis en mouvement à raison de 10 à 12 tours par minute, de façon à ce que le minerai ne puisse se rassembler au fond en masse trop compacte.

L'acide sulfurique est versé par le tube de plomb qui sert à cet éffet. Il est bon de diluer cet acide à 30° Baumé, par éxample. La cuve doit etre remplie d'eau jusqu' à la hauteur du déversoir. Le tube de plomb qui sert à l'introduction de l'acide dans la cuve est à 2 branches, dont l'une, munie d'un robinet, peut à volonté laisser venir, ainsi que nous l'avons deja dit, de la vapeur on de l'eau. La quantité d' acide varie avec la quantité de carbonate de chaux, elle est proportionelle a cette dernière, c'est à dire qu'il faudra environ 1% d' acide à 66° Baumé pour 1% de carbonate de chaux lequel est, on l' a vu, proportionnel comme l'huile à la quantité de sulfures. Tout aussitôt que l'acide est parvenu dans le recipient et qu' il a commence à se

mêler avec le minerai, là réaction commence de suite et la plus grande partie des sulfures gras monte à la surface entrainée par les bulles de gaz. Ils sont écumés ou poussés dans la petite auge qui sert de deversoir au récipient.

Une petite partie retombe et se mèle à la gangue, mais, des l' instant que les particules sulfureuses de cette partie ont été bien touchéés par l' huile, elles se separéront facilement dans le crible d' epuration auxquelles elles seront tantôt soumises.

Lorsque la réaction est terminée, c'est à dire lorsque il ne monte plus de bulles de gaz accompagnéés de sulfures au dessus du liquide, le residu composé de la gangue et d'une faiblepartie de sulfures qui y sont restées, est amené peu à peu sur le crible d'épuration.

Ce crible doit travailler par petites secousses, environ, 200 par minutes, secousses sèches et sans amplitude L' éxcentrique du crible d'éssài donne difficilement de ces secousses très répetées et cela se comprend. Il faut proceder par tatonnements.

Dans la partie industrielle le mouvement de ce crible sera donné par un appareil très simple, dont croquis A sur feuille séparée.

Par suite des secousses, la matière se répand uniformément en une couche mince sur le crible; les parties sulfurées grasses montent au dessus, gagnant ainsi l'extremité du crible, tandis que la gangue passe au travers la portion lourde en tête.

L'eau qui s'écoule par le déversoir du crible passe dans une caisse à filtre retenant les parties sulfurenses qui pourraient surnager.

Dans les appareils d'éssai, cette caisse à filtre n'éxiste pas. Il est facile de recevoir l'eau d'écoulement dans un vase quelconque percée d'une ouverture basse munie d' un filtre.

Si l'operation a été bieu conduite, il ne doit plus rester

de parties sulfureuses dans la gangue, sauf de la pyrite de fer.

Les concentrés peuvent être soumis à la presse hydraulique on au filtre-presse et par cette opération, l'on peut récupérer une très grande partie de l 'huile.

Complainants' Exhibit, Translation of Froment Description and Descriptive Matter on Froment Drawings.

29th December, 1903.

DESCRIPTION AND INSTRUCTIONS for the Concentration of Ores.

A. Description.

The machinery comprises:

1. A centrifugal mixing device.
2. A vat with coil.
3. A hydraulic purification screen, with extractors (if necessary).
4. A filter case.

The explanatory writing on the drawing already gives a fairly complete idea of the machinery, the same applies to the experimental machinery.

Nevertheless, we will give a few supplementary explanations.

A. The centrifugal mixing device is composed of a cylindrical body, made of string sheet iron rivetted with bolts, in which two stirring devices work in opposite directions, making about 300 revolutions per minute.

The ore is charged, or arrives, through a small

hopper or shoot arranged at the side, and oil is added through a small pipe arranged at the side.

(Remarks). The experimental mixing device is capable of treating about 2½ kilograms of ore per charge. The stirring devices must be made to rotate as ore with water and limestone are introduced.

For 2½ kilograms of ore it is necessary to have about 6 litres of water. Set the ore to rotate in the apparatus for a few minutes then discharge the ore without stopping the apparatus:

B. The vat with coil can be made of wood. Two such vats are required for each mixing device, in order to alternate the charges. While one is working, the other is being filled. Each vat must contain about 200 to 400 kilograms of ore. This is a matter of practice. The depth is about 0.50 metre and the diameter 1.70 metre, according to the density of the ore to be treated. A lead coil occupies the bottom of the vat. The coil in question is perforated, the holes are underneath, to avoid their getting clogged. The tube rising from the coil, is divided into two branches, one intended to receive the necessary quantity of sulphuric acid, and the other, if considered necessary, can be connected to a steam generator. Steam at low pressure arrives through the holes of the coil and assists the reactions. This is only necessary in cold countries. In case the branch in question is not used for supplying steam, it can advantageously replace the water pipe hereinafter described. (This boiler was left in the experimental machinery.)

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

A pipe con~~nect~~taining water without pressure, provided with a valve, must merge about 0.45 metre from the bottom, so as to enable the sulphides rising to the surface to be discharged. This pipe is unnecessary if it is desired to skim these sulphides or to push them towards the discharge hopper. It can be replaced by one of the two branches of the coil.

A horizontal rake turns slowly in the vat, it is operated by a vertical spindle and pulley; it must make 10 to 12 revolutions per minute.

C. The purifying screen is constituted by a frame made of hard wood, under which is fixed an aluminum plate provided with holes of ½ millimetre. The frame in question is supported by wooden uprights to which it is secured by brackets with nuts, so as to obtain the necessary inclination.

The uprights are secured to a wooden vat, the length of which is about 2.50 metres, the width 0.75 metres. The screen proper occupies nearly the whole of its surface.

The movement of the screen is effected by means of an eccentric, but it must be pointed out that the shocks must be numerous and of small amplitude, otherwise the screen will not work well.

The case is provided with three holes for the discharge of the residues, and these holes correspond to the three compartments of the case. An upper discharge tube discharges the light substances into the filter case.

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

The drawing shows three pointed extractors for continuous extraction. But in that case, a great deal of water is required. A water pipe, without pressure, provided with a valve, merges into the case about its center and slowly supplies the water required to keep the screen submerged the whole time.

D. The filter case is made of wood, it may be made of any desired dimensions—no definite measurements need be complied with in that respect. It is provided with double filters of canvas with charcoal powder in between. Water can pass through these filters, while the sulphides are kept back.

B. INSTRUCTIONS.

Practical experience has shown that, in order to arrive at a perfect disintegration of the constituent particles of an ore, without rendering it impalpable, it is necessary to do the crushing in two operations. The first time the crushed ore must pass through a sieve No. 15, either in a ball crusher mill or in a Griffin Mill or any other. The second time, it must pass through a sieve of about 120 and the crushing would be effected in a Huntington Mill, stamp mill, etc.

The output is much greater by dry process than by wet process, but there is a greater proportion of inpalpable particles. On leaving the second crushing mill, the ore will therefore be submitted to two or three "Spitzkasten" for eliminating the slime which is too fine to be treated and which could not be treated by any

hitherto known method. Reduced to the size which it ought to have, the ore arrives with a little water into the centrifugal mixing apparatus which is always working. When it is thought the quantity of the ore is sufficient (about 200 to 300 kilograms) to constitute a Charge, about 2% in difficult cases, and about 1% to 1½% of mineral engine oil are added. The mixing apparatus is left to work for about 10 minutes, the chief point is that all the sulphide grains should come into thorough contact with the oil.

(*Remark*). If the ore contains more than five per cent. of metallic matter such as copper, lead, it will be necessary to add a little more oil. As a general rule, one may assume;

1 %	of oil	for ore	containing	up to	5%	of metals
1½%	"	"	"	"	10%	"
2 %	"	"	"	"	15%	"

It is very rare that one has to enrich ore containing more than 15% copper. In our countries, Italy, France, Spain, ore containing 15% of metallic copper, is considered very rich and is treated as such. In case of lead ore, concentration is continued until the ore contains 60% of lead, this later proportion is seldom exceeded.

Consequently for a lead ore containing 20% of metallic matter, it will be necessary to use 2% of oil.

2. For ore	containing	30%	of metallic	lead	2½%	of oil
3. "	"	40%	"	"	3 %	"
4. "	"	50%	"	"	3½%	" etc

P. 1000, L. 8, insert " 1% of carbonate of lime, maximum " before " 2% "

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

It seems reasonable to assume that the proportion of the carbonate of lime follows practically the same rule, for a richer ore will require more gas than a poorer one.

The expenditure is, therefore, in proportion to the richness of the ore, and, consequently, in proportion to the metallic matter contained in the concentrated ore obtained. The process in question is more suitable for the treatment of poor ore, than for that of rich. It would be perfect, for instance, for taking up and treating sterile ore and ½ mixed ore, residues obtained from the ordinary washing apparatus more particularly when the washing apparatus in question had to treat difficult ore. However this may be, after the centrifugal mixing, the ore is discharged into the vat with coil, the mixing device being always in motion in the vat with coil.

Whilst the mixing device is being emptied of its charges of ore into the vat, the stirring device, with which the latter is provided, is started at the rate of 10 to 12 revolutions per minute, so as to prevent the ore from collecting at the bottom in too compact a mass. Sulphuric acid is introduced through the lead pipe which serves for this purpose. It is advisable to use for the purpose sulphuric aicd diluted to say 30° Baume. The vat must be filled with water up to the level of the overflow. The lead pipe which is used for introducing the acid into the vat, has two branches, one of which, provided with a valve, can be used to admit, whenever it

may be necessary, steam or water, as already stated. The quantity of the acid varies with the quantity of the carbonate of lime, it is in proportion to the latter that is to say, it will be necessary to use about 1% of acid at 66° Baume for 1% of carbonate of lime, which, as already stated, is, like the oil, in proportion to the quantity of the sulphides. As soon as the acid has reached the vessel and begun to mix with the ore, the reaction will at once begin, and the greatest part of the greased sulphides will rise to the surface, carried by the gas bubbles. They are skimmed or pushed into a small hopper which forms an overflow for the vat.

A small proportion falls back and gets mixed with the gangue, but the moment the sulphurous particles of that part come into thorough contact with the oil, it will be easy to separate them in the purifying screen in which they would be subsequently treated.

When the reaction has been completed, that is to say when no more gas bubbles, accompanied by sulphides rise to the surface of the liquid, the residue consisting of the gangue and of a small proportion of sulphides that have remained in it, is gradually brought to the purifying screen.

This screen must work by small shocks, about 200 per minute, these shocks must be "dry," that is to say sudden, and without amplitude. It has been found difficult to produce such repeated shocks by means of the eccentric of the experimental screen, which can be

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

easily explained. It is necessary to proceed by groping.

When using it on a large scale, the screen will be caused to shake by a very simple apparatus, a sketch A, of which is given on a separate sheet. Owing to the shocks, the material spreads uniformly on the screen in a thin layer. The greased sulphurous parts rise upwards, thus arriving at the extremity of the screen, while the gangue passes through the heavy portion at the head.

Water escaping through the overflow of the screen, passes into a filter-case retaining any sulphurous particles that might come to the surface. In the experimental apparatus, this filter case does not exist. It is easy to collect the escaping water into any vessel provided with a hole at a low level, provided with a filter. If the operation has been properly carried out, no sulphurous parts should remain in the gangue, except iron pyrites.

The concentrated ore may be subjected to treatment by a hydraulic press or filter press, and by that operation a very large proportion of the oil used can be recovered.

SKETCH A.

1. Iron Vibrator.
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

6. Counter-shock mounted on the vat.

7. Partitions.

8. Overflow.

9. Flexible iron stop.

10. Screen.

LARGE DRAWING.

A. *Centrifugal mixing device.*

1. Pulley.

2. Driving shaft, 60 revs. minute.

3. Large gear.

4. 4′. Gears driving the stirrers 300 revs/min.

5. Hopper for charging in ore coming from the crusher.

6. Safety (overflow) pipe discharging into any vessel.

7. 7′. Vessels receiving the ore after the centrifugal mixing.

8. 8′. 8^2. Iron frame supporting the mixer.

9. 9′. Water pipes with valves for expelling the ore from the vessels, 7 and 7′ and introducing it into the coil vat.

B. *Coil Vat.*

1. Vat proper made of wood.

2. Table supporting the vat.

3. Overflow discharging sulphides into the filter case.

4. Pulley and shaft driving the rake in the interior.

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

5. Discharge tube for the residue.

6. Drain pipe for the coil.

7. 7′. Two-branch tube of the coil.

C. *Purifying Screen.*

1. Screen case.

2. Water pipe with valve used, when necessary, for maintaining the case always full of water.

3. Pulley and shaft driving the screen.

4. 4′ 4^2. Supports of the screen.

5. Aluminum screen, wood mounted.

6. 6′ 6.″ Discharge pipes for the residue.

7. Discharge pipe for the light sulphides falling into the filter case.

8. 8.′ 8.″ Residue in extractor, for the case that it is desired to classify it.

D. *Filter case.*

1. The case proper.

2. 2′. 2.″ 2.′″ Canvas filters consisting of a wooden frame with canvas stretched on both sides.

Between the two canvasses is contained charcoal powder.

4. Emergency discharge pipe.

Complainants' Exhibit Fryer Hill Publication.

(The Daily Herald Democrat, Leadville, October 30, 1889.)

AN IMPORTANT INVENTION.

Experiments with the Oil Rotary Concentrator.

One of the most novel methods of treating dry silicious ores ever brought to notice—an exhaustive review of the new process—its advantages particularly applied to the miners of Fryer Hill—news from the mines—shipments from the new quartzite strike—Mikado's new developments.

Experiments are now being made in Denver with a new appliance for the concentration of dry silicious ores, such as those of the Dunkin, Matchless, Little Silver, and, in fact, all the mines of Fryer Hill. So far, the experiments have proved a perfect success, the tailings from the concentrator, if so it may be called—only running one ounce to silver from a crude ore that ran over ten ounces of silver per ton. The first unimportant means of testing the new system having proven so incontestably the correctness of the theory, other larger and more capable means have been employed. The whole system of concentration appears to be based on the well known affinity of the lighter forms of sulphuret and chloride of silver for oils. Petroleum is the oil now being used by the parties having these experiments in charge, and appears from its density,

to possess the requisite adhesiveness to effect the result desired. The ore is first crushed and rolled to such a degree of fineness as to enable it to pass through a 40 mesh screen, and while dry, is thoroughly mixed with the oil, after which it is placed in a circular tank or receiver, through the center of which runs a rotating hollow tube, to the bottom of which tube is attached, on two opposite sides, a couple of fans, the lower edges of which are unevenly cut in order to send—in the revolution—the lighter particles of the ore and oil mixture to the outer sides of the drum or cylinder. This rotating hollow tube is perforated at, or near, the bottom, and, when the receiver is thoroughly charged, acidulated (sulphuric acid is used). Steam is introduced through the tube and is forced to the bottom of the mixture, while the arasta-like fans, attached to the bottom of the tube, keep the whole mixture in motion, and the action of the revolving tube, the fans, and injected acidulated steam causes the lighter portions of the mineral-charged oil to float to a point just above the center of the receiver, where there are suspended two semi-circular doors, which, when the oil has passed above them, laden with its precious freight, are raised, and the superfluous water allowed to drain through slight perforations in the bottoms of these semi-circular doors, after which the mineral laden oil is carefully removed to settling barrels revolving with jets of steam injected continuously from the lower ends. These settling barrels being placed at an angle, permit the min-

eral laden oil to pass through openings in the ends, which are connected with shallow settling tubs or tanks from which the concentrated ore is shipped directly to the smelters, who will hardly be likely to refuse so pleasant an addition to their heating powers. As said above, with the present plant, which is daily being improved upon, a good, high grade concentrate is being made on ores on which no previous methods of saving the silver value has proven entirely satisfactory, and the few mining men of Fryer Hill to whom this scheme has been whispered are watching the experiment with a great deal of interest, as there are thousands of tons of such ore now awaiting treatment.

Complainants' Exhibit Criley & Everson Publication.

Nov. 15, 1890—581.

THE ENGINEERING AND MINING JOURNAL.

OREGON.

Baker County.

Baker City, Nov. 10.

Quite a number of capitalists from Portland and Walla Walla are here watching the result of some test working of the "Criley & Everson Oil Process" for the extraction of sulphurets from any ore as the name signifies by the use of oil. Your correspondent witnessed a test made on the Eureka and Excelsior ore, which was conducted as follows: The ore was crushed and passed through a 50 mesh sieve, weighed and thoroughly mixed with black thick oil. To water heated to near boiling was added enough sulphuric acid to give it a tartish taste. This acidulated water was then mixed with the mass of oil and ore. A thick scum of sulphurets rose to the surface and was skimmed off, leaving the hitherto black ore as white as snow—in fact, pure silica. The gentlemen expressed themselves as pleased and the citizens of Baker County are in hopes they are, because it means the erection of a large plant at this point.

Complainants' Exhibit of Statement of Profit Lazard Ventures.

Statement of Profits Made by Ventures a/c by Treatment of Material in Minerals Separation Ld. Tailings Plant with Agitation-Froth Process.

	Total.	Lazard Bros.	M. S. Ld.	S. C. Ld.
Original Joint Venture	£130341- 8-10	£65170-14- 5	£65170-14- 5	
Triple Venture	51024-11-11	12756- 3- 0	12756- 2-11	£25512- 6- (
South Blocks Venture	321- 5- 0	160-12- 6	160-12- 6	
Total	£181687- 5- 9	£78087- 9-11	£78087- 9-10	£25512- 6- (

HCH
3/9/1

Complainants' Exhibit Table of Material and Results Lazard Ventures.

Table of Material Treated and Results Obtained in Minerals Separation Tailings Plant with Agitation-Froth Process.

Period	Material	Feed Tonnage.	Concentrates Produced Tons.	Realized Value
ORIGINAL JOINT VENTURE				
November, 1907, to September, 1910.	Dump Tailings,	481,859	170,290	£506,417
TRIPLE VENTURE				
September, 1910, to April, 1911.	Dump Tailings,	50,000	14,073	
	Magnetic Tailings,	65,682	17,316	93,419
JOINT VENTURE (South BLOCKS).				
April, 1911, to June, 1911.	Middlings	39,258	14,502	35,535
	Total	636,799	216,181	£635,371

COSTS.				
Paid for Tailings, per ton	Tails	5.04	£160,553	
Total Cost of Plant Management, Treatment, Interest, Realization, etc. (everything included)	do	9.20	£293,130	£453,683
NET PROFIT	do	5.71		£181,688

HCH
8/8/12

Complainants' Exhibit Statement of Expenditures in Agitation-Froth Process.

Statement of Expenditure incurred by Minerals Separation, Ld., in Introducing the Agitation-Froth Process to 31 Dec., 1911.

Plant and Laboratory Apparatus		£9,317-1-2
Experiment al & General Expenditure		
Management, Traveling Staff, Examination of Properties at home and abroad,		62,115-16-5
London Administration.		
Office Salaries & Rent,	£5,569-17-11	
Legal Charges,	1,027- 7-	
Audit Fees	177-19- 6	
General Expenses,	3,428- 6- 5	
Postages and Cables	2,193,13- 9	
Interest	320-11- 9	
Directors Fees	7,378-14- 8	
		20,096-11-
		£91,529- 8-7

HCH
4/8/12

Note:

The expenditure incurred in Purchases of Patents, Patent Fees & Expenses & Patent Litigation and amounting in all to £56,481-0-10 is not included in the above statement.

Complainants' Exhibit Statement of Expenditures by American Syndicate in Agitation-Froth Process.

Statement of Expenditure by Minerals Separation American Syndicate, Ld., in the introduction of the Agitation-Froth Process to 31 July, 1912.

(1) Into United States of America	£12,360-15-5	
(2) Into Mexico	1,401-16-8	
(3) Into Canada,	1,433- 9-7	
		£15,196-1-8

HCH
2/9/12

The above statement does not include any litigation expenses, or any of the Costs in the present suit.

Complainants' Exhibit Statement of Tonnage Treated by Agitation-Froth Process at Broken Hill, Australia.

Tonnage of Tailing & Slimes treated by Minerals Separation Agitation-Froth Process at Broken Hill, Australia, with Concentrates produced as per official returns made by Licensees.

	Tailings & Slimes—Tons.	Zinc, Lead Silver Concentrates—Tons.
Sulphide Corporation, Ld. Part year ending 30" June, 1906, 30 June, 1912,	1,176,934	445,299
Minerals Separation, Ld. Jointly with Lazard Bros. & Co. & Sulphide Corporation, Ld. November 1907, to June, 1911.	636,799	216,181
Zinc Corporation Ld. Nov. 1910 to 30 June 1912	380,020	132,675
Broken Hill Junction North Nov. 1911 to 12 March 1912.	44,261	10,449
	2,238,014	804,604
Zinc Corporation Ld. April 1907 to Oct. 1910	No Returns of tonnage made but they paid £1500 in Royalties equivalent to 12,000 tons of Concentrates.	

HCH
4/9/12

Complainants' Exhibit Statement of Profits and Royalties on Agitation-Froth Process.

Minerals Separation Ld. Proportion of Profits from Joint Ventures and Royalties received from Licensees.

Original Joint Venture		
Total Profit	£130,341- 8-10	
Minerals Separation Ld. proportion ½		£65,170-14- 5
Triple Venture.		
Total Profit,	51,024-11-11	
Minerals Separation Ld. proportion ¼		12,756- 2-11
South Blocks Venture.		
Total Profit	321- 5	
Minerals Separation Ld. proportion ½		160-12- 6
Total M. S. Ld. Profit,		£78,087- 9-10
Royalties received from Licensees as far as accounted for and received in London to 30 June 1912		£75,166- 0- 6
Royalties due but not yet paid or received in London at 30 June 1912 are excluded		
		£153,253-10- 4

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

Complainants' Exhibit, Table of Sulphide Corporation Operations With Agitation-Froth Process.

Tonnage Treated	1,176,934 tons
Concentrates Produced	445,299 tons
Total Value	£1,154,353.
Per ton Feed	
Shillings	
19.6/-	
less Total Cost of treatment	£504,200.
8.5/-	
Profit, 11.1/-	£650,153

Complainants' Exhibit Sulman & Picard Report March 25, 1903.

SULMAN & PICARD.

44, London Wall, E. C.

25th March, 1903.

John Ballot, Esq.,
Salisbury House, E. C.

Dear Sir,

As you are aware we have carried out numerous experiments on the Cattermole process during the past 2 months, the work done being mainly of a preliminary experimental character with a view towards getting a knowledge of some of the chief factors involved.

Whilst we were feeling our way much of the work

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

done was not of a quantitative nature and therefore no detailed records were necessary. Of late however work done has been strictly quantitative and a schedule of results is appended hereto. It will be perhaps the most convenient way if we here state the general results arrived at from the whole series of qualitative and quantitative tests without considering each test separately. Firstly, we have endeavored to reduce agitation i. e. flocculating, breaking down, and rolling or agglomerating actions, to a mechanical standpoint and therefore have used the Gabbett cone and a mechanically rotated cylinder for all the later agitations required.

We early got away from the alkaline soap method of breaking down the first product resulting from the treatment of an ore with soap and oil emulsion by means of which the whole of the ore is precipitated from the milling waters as one uniform flocculent precipitate. This flocculating operation remains much the same as schemed by Cattermole originally. The next portion of his invention was to "break down" the flocculent precipitate into clean gangue and fine particles of oiled mineral by more or less violently agitating the flocculent precipitate with weak soap and alkali. By rolling or agglomerating the product so obtained the oily particles of mineral are made to cohere into gradually increasing shot-like granules, when they become sufficiently dense to be separable from the coarse clean sands or gangue by the action of an upward current of water.

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

The combined minerals in the form of clean granules may then undergo further separation into their constituent minerals by the application of solutions of increasing strength in alkali.

Our work up to the present has been confined entirely to Broken Hill sulphide ores. This is a type of mineral which gives the greatest difficulty in the separation of gangue from mineral; the gangue is exceedingly heavy consisting as it mainly does of garnet and rhodonite—its specific gravity being nearly twice that of quartz, and varying from 4.3 to 4.7; and thus very nearly approaching in density that of the blende contained in the mineral. There being no difficulty in the separation of blende from galena when once the separation of the two from the gangue has been effected, we have confined our investigation so far entirely to separating the gangue from the combined mineral.

So far the process described is covered by the provisional specification which Cattermole has already filed, but it was found difficult to separate such heavy gangue as exists in the Broken Hill ore from mineral by the *alkaline soap* "breaking down" method. It was found however that the treatment of the first flocculent precipitate by very dilute acid gives an easy and complete result and therefore the acid breaking down process has been exclusively used by us in all our late work. This is a most important development of the Cattermole process and will have to be protected by further specifications. Most of the earlier experiments, in fact all

but the last one given in the schedule of results (No. 6) were made upon Broken Hill ore ground to varying meshes from 90 mesh to 120 upon a Bucking table. The results on these were very satisfactory allowing for the imperfect form of upcast apparatus used for separating the mineral granules in the last operation. The last experiment however was made upon ore ground by Messrs. Johnson & Sons of Finsbury, 5 cwt. of Broken Hill being ground, 3 cwt. to 60 mesh and 2 cwt. to 120 mesh. Mr. Cattermole and ourselves found much greater trouble in treating this material than in dealing with laboratory crushed ore. The 120 mesh material was found to be nearly all fine slimes, containing a very large proportion of free zinc blende in a state of high division, whilst the 60 mesh stuff was far more granular and contained very little slimes and much coarse sands. After many experiments however the difficulty in dealing with these products has been largely overcome and the last experiment on the schedule shows the result on 800 grammes of 60 mesh ore conducted in 3 separate lots.

Kerosene emulsion of 75% strength was used in the earliest experiments, and though this oil works well, and in the rolling operation (after breaking down) yields hard shot like granules, it has the disadvantage of not taking up all the blende, leaving the sands and slimes somewhat dirty with unrecovered zinc sulphide. It has been found that the substitution of thick residuum oil for the larger portion of kerosene used in the

emulsion gives quite clean sands and retains every portion of the blende; but thick oil seems to leave the granules somewhat more readily affected by air, giving rise to floating granules whenever a pulp in which they are contained is exposed to the air. Pure kerosene granules also do this to some extent and we are not yet sure whether this may not be due to the acid breakdown as compared with the original alkaline method; if so it is a difficulty which has to be overcome, as there can be no doubt that the acid breakdown is five or six times as cheap as the original alkaline soap method. The obvious remedy is to keep the granules and sands after the rolling or agglomerating stage carefully covered by water during their transference into and below the surface of the water in the upcast separating apparatus, for which purpose an open launder should *not* be used; but possibly some form of submerged archimedean screw feed might be used on a large scale.

Facts which have been established so far are broadly as follows: Sharp ore alone does not give such good results as a mixture of sharp ore with slimes, as the fine mineral particles in the latter exercise a potent effect in building up the hard shot like granules desired, by supplying "filling material" without which the large oiled mineral particles could not become sufficiently coherent or dense. Again slimes containing mainly, or only, blendes, are not so suitable as those which contain their due proportion of fine galena, also, as blende is the mineral most difficult to take up by oil, and the first to be

rejected in subsequent separations. It does therefore not form such good filling or cementing material for granules as does galena; but with a fair proportion of the latter ("fines") there is no difficulty in getting the blende to do its proper share of cementing work in forming the granules. These factors are those which mainly have to be considered in the original grinding of the raw ore. It becomes therefore obvious that when the mineral is ground to 60 or 70 mesh that all slimes produced should be kept strictly associated with the coarser particles and that the slimes so produced should not consist exclusively of the more readily slimed blende but a fair proportion of galena slimes should also be present. Given these conditions the operation of the Cattermole process has become much simplified compared with the scheme originally put forward. It is sufficient to take the ore suspended in about three to four times its weight of water and to mix this to a uniform pulp in a suitable mixer preferably of the Gabbett type; to this suspension, while still in a state of agitation, the oil emulsion is added. The proportions requisite may vary somewhat and are shown in the schedule. Roughly speaking we have found that the oil addition equal to about 7% upon the mineral present in the ore is sufficient. A small amount of soap solution is also necessary to obtain good flocculation and it appears to aid in the uniform dissemination of the added oil emulsion through the pulp in the mixer. A very short period of agitation is necessary to effect complete floc-

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

culation of the whole of the mineral, which readily subsides, leaving clear water above, opalescent with the soap added. The tendency of our work has been to show that a very small amount of soap is necessary and we have continually cut this down, almost to the vanishing point; still a small amount of soap during flocculation appears to be advisable. The clear solution still containing this small amount of soap is run off from the flocculent precipitate and can be used perfectly well on the next lot of mineral to be flocculated. The whole of the oil added as emulsion appears to be taken up by the ore, and none to remain in the opalescent but otherwise clear liquor. The flocculating precipitate is so open that it drains most readily from any remaining liquor which cannot be decanted. The flocculent precipitate may even receive a plain water wash with advantage. The mass is then put into about three to four times its own volume of very dilute sulphuric acid which may vary between the limits of 0.05% to 0.1%. Somewhat violent agitation is now required for a period of a few minutes; the time being dependent upon the efficiency of the agitation, and varying from 2 to 5 or 8 minutes, whereby the oil is released from the gangue and attaches itself exclusively to the mineral. The mass changes in color and becomes much lighter owing to the liberation of the pinkish-white gangue, but the mineral remains disseminated through this mass in extremely fine granules which require to be agglomerated by rolling treatment. It is however found advisable before such rolling treat-

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

ment is given to pour off or decant at least half of the liquor resulting from the breaking down, and, *with this,* to include as much of the fine but now clean gangue slimes as possible as the presence of very fine gangue slimes seems to interfere somewhat with the attaining of hard mineral granules. The pulp, which now consists of very fine oiled mineral particles dispersed through clean gangue from which the finest slime gangue has been separated, is placed in a cylinder and rotated about its horizontal axis at the rate of about 60 to 80 revolutions per minute (for a 4″ diameter cylinder) for about ten minutes. This gentle rolling action has the effect of making the mineral particles cohere and build up into the shot-like granules required. When these are found to be of sufficient size the rolling operation is stopped and the mass separated in any convenient or efficient upcast water separator. We have naturally not been able to try the experiments on a sufficiently large scale to give definite factors as to the amount of rolling travel requisite for the agglomerating in large scale plant. In a 4″ cylinder about 1,200 ft. of such rolling travel is necessary, but, with increasing quantities the "mass factor" we find, constantly tends to reduce the amount of rolling travel, and it will probably be much less than the amount mentioned when larger apparatus is employed. We are constructing a cylinder of 8″ in diameter and 2′ in length fitted on the interior with slotted partitions and with a continuous inflow and discharge which will enable us to get at such a figure

far more exactly. Finally, it is not always possible in the upcast apparatus used by us on the laboratory scale to effect in one operation a sharp separation into absolute gangue on the one side, and clean granules free from gangue, on the other. Whilst the heaviest granules come away quite clean, and the lighter sands are easily eliminated, a middle portion is apt to be formed consisting of lighter mineral granules mixed with the heavier sands; and any attempt to treat this middle portion is apt to drive over some of the smaller mineral granules with the heavy sands. We thus find it best in tests with our present small laboratory apparatus (with which it is very difficult to obtain uniform conditions and therefore uniform sized granules) to pass our rolled product through the upcast apparatus *at first* with only a comparatively light up-current of water. This rejects the bulk of the gangue as light sands, but gives a product containing all the granules mixed with some heavy sands. If this second product be then given a short further rolling treatment the fine granules become much larger and agglomerated with the heavier granules, and this product is then capable of a ready separation from the remaining heavy sands in a sharp up-current of water.

It is obvious that many variations of such separation treatment are possible, and that with a little experience a very simple and efficient form of apparatus could be devised. Combinations of such apparatus could be placed in series to deal with the various sand and gran-

ule products without the necessity for a second rolling agglomeration, but up to the present the facilities at our disposal, and the small scale upon which alone it is possible to work in the laboratory, have prevented us from using any but the simplest plant. The chain of operations is therefore extremely simple.

FIRSTLY. Suitable crushing of the ore as specified.

SECONDLY. Flocculating the pulps with a small amount of soap and oil emulsion in the proportions given using a fair proportion of thick oil to kerosene. (It is only necessary here to note that emulsions containing thick oil are rather more difficult to get completely "smooth" that is, free from unemulsified oil globules, than with kerosene alone; but with a little care and experience a perfect emulsion of thick oil is obtainable).

THIRDLY. Breaking down the flocculent precipitate by strong agitation with very dilute acid.

FOURTHLY. Gentle rolling to agglomerate the fine mineral particles into shot like granules.

FIFTHLY. The separation of granules from gangue in a water up-current.

We are, dear Sirs,

Yours truly, SULMAN & PICARD.

Complainants' Exhibit—Sulman & Picard Report
March 25, 1903.

ADDENDUM TO REPORT.

We omitted to state that in our last experiment, No. 6, a further simplification has been made which seems to promise well. The flocculating stage has been abandoned and .05 to .1% acid has been used *direct* for suspending the duly crushed ore in. The addition of *"thick oil plus paraffine" emulsion* has been made direct to this, and after a sufficient agitation period has been given to the mixture, the gangue is found to be free and clean whilst the mineral is disseminated through this in a state of very finely divided granulation. On pouring off the bulk of the acid liquor, together with any *fine* clean slimes which it may contain, and rolling the remainder as usual, excellent granulation has been found to occur. We are not yet sure how this treatment may act with finely ground mineral slimes containing much blende, but experiments are in course to determine this.

S. & P.

Complainants' Exhibit Sulman & Picard Report May 5, 1903.

SULMAN & PICARD,

44 London Wall,
London, E. C.
May 5th, 1903.

John Ballot Esq.,
607, Salisbury House,
London Wall, E. C.

Dear Sir:

CATTERMOLE PROCESS.

We beg to report results of experiments on the above process.

Expt. No. 7. This test was made on Broken Hill ore ground to 60 mesh. 1000 grammes of ore was used in two lots of 500 grammes each, as the Gabbett mixer will not take more than 500 grammes, which portion was agitated with 600cc. of 0.2% Sulphuric acid and 30cc. of Soap emulsion. The emulsion was made up of 50% of oil and 2% Soap; the oil being a mixture of two parts of residuum and one part of paraffine.

This charge was agitated about 10 minutes, half the time with the baffle, and half without. The two charges were then mixed and submitted to the rolling process in the Gabbett (without baffle) for a period of three minutes. This treatment yielded satisfactory granules.

The charge was then put through an upcast separator to remove the light sands.

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The heavier portion was rolled in a cylinder, especially made for the purpose. This however did not have any beneficial result, but on the contrary, rather tended to destroy the granulation which had previously been obtained. This is probably accounted for by the small quantity of ore used relative to the size of the cylinder so that during the whole of the rolling the granules were exposed to the air thus producing a considerable amount of float.

The charge was next put through the upcast and yielded

Concentrates	450 grammes
Tailings	504 "

The loss in total weight is due to a certain amount of mineral being left in the cylinder.

The original assay of the ore used for this test was as follows:

Zinc	15.93%
Lead	16.71%
Insolubles	48.35%

The Concentrates contained 6.6% of gangue, the balance being a mixture of Galena & Blende, which was not analysed.

The tailings assayed:

Zinc	1.09%
Lead	1.63%

Neglecting the amount of ore left in the cylinder the recovery in the concentrates equalled:

Zinc	96.3%
Lead	94.85%

This and other experiments have led us to conclude that the rolling process in a separate cylinder might be omitted and that the whole process can be carried out in the Gabbett. A test was carried out on a similar class of ore with the object of determining the correctness of this view.

Expt 8. As nearly as possible the conditions of this experiment as to the value of the ore, strength of the oil solution, time, etc., were maintained as in the previous test. After treatment of the two lots of 500 grammes in the Gabbett, the two products were mixed together and re-treated by rolling in the Gabbett, from which the mixture was passed direct through the upcast and the light sands taken off. The coarse product was then slightly acidulated and re-treated in the Gabbett for 7 minutes and again put through the upcast. This treatment resulted in three products which consisted of:

557 grammes concentrates.
205 " light sands from the first upcast.
200 " tailings.

The original assay of the ore used in this test was as follows:

Zinc	15.86%
Lead	19.69%
Insolubles	39.9 %

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The concentrates contained:—11.65% insolubles.

The light sands assayed:

Lead	4.29%
Zinc	1.88%

The tailings assayed:

Lead	2.24%
Zinc	0.91%

The final recovery therefore amounted to 96.4% of the Zinc, and 92.06% of the Lead, or a mean recovery of 95.1% of the total metals present in the original ore.

These encouraging results have decided us to erect a model plant on the Gabbett system which will be capable of handling probably 50 lbs. of ore per day. This plant is nearly complete, and will have its first trial during the course of this week, the results of which will be immediately reported to you.

Yours faithfully,

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report September 24, 1903.

SULMAN & PICARD,
24th September 1903.
44, London Wall, E. C.

John Ballot Esq.,
607, Salisbury House, E. C.

Dear Sir,

RE CATTERMOLE PROCESS.

We beg to append report on the progress of investigation of this process up-to-date. Since our last report a very great amount of work has been gone through, both independently by Mr. Cattermole and by ourselves, aided by our assistants Messrs. Pudsey & Chapman. The work done may be summarised briefly by the letters we wrote you.

FIRSTLY. On July 14th '03, advising you that the Cattermole process was completed to our satisfaction so far as the granulation step was concerned.

SECONDLY. Our letter to you of July 27th '03, advised you to complete the patent for the second or breaking down step as although the trials were not complete considerable progress had been shown in this direction.

THIRDLY. On August 11th, we advised you to

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complete the breaking down process patent, and expressed the opinion that this second step now showed the prospect of being a considerable commercial success.

The work done has been so voluminous including many interviews with patent agents and patent counsel (Messrs. Terrell K. C. & Gordon K. C.) that we need only briefly refer to the chief lines of investigation. We enclose you herewith a tabular view which we drew out for the aid of counsel, setting forth the chief reactions involved in the Cattermole Process.

Firstly we will summarise Mr. Cattermole's independent work.

NAGYAG ORE. (Poor). Acid granulation apparently useless. Alkali granulation using emulsion of residum oil 2 parts, paraffin one part, gave fair results. In this case emulsions and circuits containing natural soaps worked best.

Assays, original ore:

Gold	0 ozs.	2 dwts.	21 grns.
Silver	3 "	18 "	12 "

Concentrates obtained:

Gold	0 ozs.	11 dwts.	8 grns.
Silver	26 "	12 "	3 "

Tailings:

Gold	0 "	0 "	16 "
Silver	1 "	5 "	13 "

A second sample gave good granulation in the same

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type of circuit, but using as emulsion oil residuum 2 parts, paraffine 1 part. *A richer sample* of ore was worked upon the original assay was not taken, but the concentrates obtained showed:

Gold	6 ozs.	10 dwts.	6 grns.
Silver	45 "	14 "	16 "

Tailings:

Gold	0 "	3 "	22 "
Silver	1 "	15 "	8 "

A considerable interval ensued, during which time *a complete experimental plant was installed.* This consisted of a series of 6 circular glass vessels, each fitted with a revolving cone agitator, the necessary power being derived from a ½-H.P. electric motor. The series of agitation vessels were divided into two, one of four units, the other of two. With each of these sets an up-current separation device was placed in circuit for the purpose of the separation of the granules of mineral from the depleted tailings. The plant also included a mechanical ore feed, and a glass emulsion tank fi~~ll~~tted with agitat~~ion~~or, together with liquor reservoirs and return pumps. After a few weeks the whole plant was put in satisfactory running order, and the dimensions of all pipe circuits, rates of agitation etc., etc., satisfactorily fixed. A series of tests upon Broken Hill ore then followed and demonstrations of the working plant were given to yourself and friends associated with you namely, to Messrs. F. A.

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Govett, Mr. H. C. Hoover, Mr. W. W. Webster and also to patent counsel, Messrs. Terrell K. C. & Messrs. Gordon K. C. The plant operates as follows: The vessels and separation circuit are filled throughout with water, which may be either acid or alkaline, according to the requirements of the ore to be treated; in the case of Broken Hill a circuit of .2% sulphuric acid was employed. The dry crushed ore is fed by the mechanical hopper into the first cone agitator, where it also receives the due continuous addition of emulsion from the emulsion tank above. After receiving its due rolling agitation herein it continuously passes into the second vessel where a like agitation is given, thence into the third vessel and into the 4th. By this time granulation is well established and the fine sands and slimes are sufficiently clean to enable them to be removed; this is done by their continuous passage through the first up-current separator. The fine slimes are rejected and after settling the liquor is returned to the ordinary liquor circuit; then the heavy sands, together with the mineral granules, are continuously passed from the bottom of the separator into the fifth and sixth cone agitators, where, by a continuance of the rolling agitation the mineral granules are so increased in size (and therefore in specific gravity) as to enable them to be finally separated from the heavy sands by passage through the second upcurrent separator.

The concentrations of Broken Hill ore effected in

this plant have been exceedingly satisfactory, both slimes and sands almost mineral free having been obtained, whilst concentrates continuously and automatically delivered from the exit tube have been of high grade. The plant has shown itself capable of continuous work and to have a capacity of about half a ton per 24 hours, although the vessels were of such small size, the glass agitators not exceeding the working depth of six to seven inches with a diameter of 4½ to 5 inches. If these dimensions be merely cubed there seems reason to estimate that such a larger plant would treat 50 tons of material per day. A sample of *Rosebery* ore was also treated in this apparatus, the material having been crushed to 60 mesh. This was a copper-blende ore and granulated well, yielding a particularly clean gangue, whilst concentrates obtained "broke down" excellently into separate copper and zinc products, by the use of a 2% soft soap solution with 2% of caustic potash. Here, as in other experiments, the fact was brought out that if emulsions containing only lighter paraffine oils be used instead of those containing "residuum" that weaker alkaline solutions are able to effect the breaking away of blende from the concentrates. This is, however, to some extent, counterbalanced by the fact that light oil emulsions for the same class of reason do not so readily granulate fine blende-containing ores, and that an emulsion containing heavy residum oils is preferable to effect the ready cleaning up of zinc-blende ore slimes.

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We experienced considerable difficulty at first in determining the minimum mesh to which it was necessary to grind the Broken Hill ore experimented upon. We had several parcels crushed to various meshes by Messrs. Johnson & Sons. The first two parcels were ground to 60 and 120 mesh respectively, the 60 mesh sample appeared to work fairly well, but considerable difficulty was found in dealing with the 120 mesh product. In order to ascertain the reason of the difference, several assays were made.

The 60 mesh material gave the following results:

Gangue and insoluble	39.0%
Lead	19.69%
Zinc	15.85%

A sieving test was also made which showed:

Remaining on 60 mesh	2.5%
" " 90 "	.5%
" " 120 "	43%
Passing through 120 mesh	54%

Whereas the 120 mesh material showed on assay:

Insoluble and gangue	62.35%
Lead	8.45%
Zinc	9.4%

A check assay on another sample of 120 mesh also showed:

Insoluble and gangue	66.55%
Lead	7.17%
Zinc	8.85%

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A sieve test showed:

Remaining upon 200 mesh	35%
Passing through " "	65%

The two parcels were therefore entirely different in nature, the 120 mesh product being so poor and differing so much from the original ore as to give rise to the suspicion that it had been derived by sifting the finer portions of the 60 mesh product, although strict instructions had been given that such a method of producing 120 mesh material was not to be followed. We were confirmed in our belief by the fact that fresh Broken Hill ore reduced to 120 mesh on the bucking table was found to granulate quite readily. Fortunately, the succeeding fortnight's experiments which were carried out, not only in the large test plant, but in a small independent Gabbett cone mixer, subsequently erected for experimental work, demonstrated that it was unnecessary to reduce Broken Hill ore beyond 60 mesh in order to secure excellent results.

A certain amount of fine material as well as coarse is necessary to the building up of coherent granules, but the sieve analysis of the 60 mesh material just quoted shows that upon crushing to this maximum mesh quite a sufficient amount of material finer than even 120 is produced for all granulation requirements. The first granulations obtained from a trial on the new plant yielded concentrates containing 20.85% of insoluble matter i. e. gangue. Too much oil emulsion had been

used in this case and by further reduction (to about 6%) granulation was found not to be interfered with, and the concentrates only retained 12.15% of insolubles. A still further reduction was made in the oil additions when it was endeavored to add oil emulsion in the proportion of about 5% of oil upon the actual mineral present in the ore. The concentrates obtained contained:

Lead	30.73%
Zinc	24.65%
Moisture	1.7 %
Oil	5.35%
Insoluble	11.91%

The concentrates were thus of excellent quality, but the sands both coarse and fine were not quite freed from mineral. The fine sands were found to contain:

Zinc	5.115%
Lead	8.19%

The coarse sands contained:

Zinc	3.07%
Lead	6.59%

It was found however that the coarse and fine sands which still contained mineral values, held these in a partially granulated state, and their inclusion in the sands was due,

(a) to insufficient granulation,

(b) to the difficulty of making an absolutely sharp sep-

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aration in the up-current separators employed. Mixing these two products together and re-agitating them in vessels 5 & 6 of the trial plant, the remaining mineral contents regranulated yielded an almost absolutely sharp separation from the sands. We have here only briefly summarised granulation work done to date, although the actual experiments extended over a considerable period; details of many negative trials necessary to establish these conditions can be seen in our own and Mr. Cattermole's notes.

The results obtained however fully justify, we think, our advice to you to exercise your option with regard to the granulation portion of the Cattermole process.

We next devoted our attention to the "breaking down" invention and for a time had little but negative results to chronicle. Mr. Cattermole found great difficulty in separating the blende from the galena in Broken Hill concentrates; we pointed out that caustic potash was too expensive an alkali for commercial employment and requested him in future to confine himself to the employment of caustic soda. This alkali has the disadvantage of producing rather more insoluable soaps and emulsions and some investigation was required to fix a fresh series of minimum strengths for its use in place of caustic potash.

Again the use of plain paraffine emulsions had been discontinued for some time for granulation purposes in favour of emulsions containing from a third to a half of their oil contents of residuum. This material, owing to

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its viscosity, was found to be less readily emulsified than paraffine and therefore to give greater trouble in breaking down. These unexpected results gave a temporary check to the development of the breaking down process (now generally referred to as "classification") and in order to economise time Mr. Cattermole worked mainly by bottle methods, independently of our own investigation aided by Messrs. Chapman & Pudsey in the endeavour to overcome this difficulty. Various forms of mechanical apparatus were devised by Mr. Cattermole and ourselves with the object of aiding the breaking-down liquors. Gabbett cones driven at increased speed and supplied with additional rotating and stationary baffles were first used, but without success. A type of apparatus capable of even more violent agitation was then bought, on the type of an egg-beater, which gave slightly better results. In order to confirm Mr. Cattermole's contention that attrition of the granules with the breaking down liquor was needed to effect a separation, a small clean-up pan was bought from Messrs. Fraser and Chalmers and added to the trial installation. This certainly aided considerably in classification and the first definite result in splitting up the granules obtained from the trial plant into blende and galena products, was obtained in July, by Mr. Pudsey.

The zinc product showed on assay:

Zinc	42.35%
Lead	14.08%

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The lead product contained.

Zinc	9.91%
Lead	64.03%

Though neither of these products is sufficiently good the figures mark a considerable advance on anything previously done. Mr. Cattermole, in the meantime, came to the conclusion that it was impossible to separate the whole of the blende in one operation, but, that as in granulation, it was advisable to separate the fines (blende) firstly and to treat the product containing all the galena and the coarse blende with a somewhat stronger solution to effect the separation of the latter mineral. He also found that the breaking down solution should also be "fed" with a certain amount of fresh oil in order to prevent it from taking out too much of the oil held by the granules i~~s~~n the first breaking down stages. Many excellent separations were obtained by him on the bottle scale about this time, but we did not consider it advisable to analyse any of these products or to be content with any results not obtained by the mechanical means. Towards the end of July, working in the independent Gabbett mixer upon the lines just specified, Mr. Cattermole succeeded in obtaining the following classifying products:

1. BLENDE SLIMES.

Zinc	43.12%
Lead	12.32%

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2. COARSE BLENDE.

(Representing the bulk zinc product)

Zinc	44.6 %
Lead	9.28%

The bulk of the lead product showed:

Zinc	6.45%
Lead	77.79%

These results again show further improvement. Jigging methods for the separation of blende from galena granules did not give such good results; the lead product remaining giving an assay of:

Zinc	16.8%
Lead	52.5%

Mr. Cattermole now devised 3 or 4 different types of beating separators which he constructed and experimented with, and which combined factors of violent agitation, a continuous upward but pulsating flow, and to some extent gradation and the separation of particles by the use of a cone shaped vessel. The results obtained, though giving indications of promise, were not sufficiently conclusive to permit us to advise you to continue experimental plant expenditures in this direction. At a later date, however, it may be advisable to go over a portion of this ground again. The use of residuum was now reduced to a minimum in the granulation process, paraffine being mainly employed; using such, and paying great attention to the rapidity of agitation employed

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in the breaking down process, and also the proportion to be observed between breaking down liquor and granules (these factors being established mainly by independent work done by ourselves and staff), Mr. Cattermole in August, finally produced the following classification results:

FINE BLENDE PRODUCT.

Zinc	46.38%
Lead	8.003%

COARSE BLENDE PRODUCT.

Zinc	49.09%
Lead	4.48%

This when mixed together gave an average zinc product assaying:

Zinc	48%
Lead	6%

The lead product showed a contents value of,

Zinc	6.05%
Lead	66.59%

We need hardly say that we consider that these results, showing as they do that it is ~~im~~possible to obtain by means of Cattermole's process excellent smelting products, in both cases free from any smelting penalty, justified us in advising you to complete your option upon the breaking down portion also of Cattermole's process. We do not propose here to give a detailed resume of all the experimental work done by us during

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this period, but we append one list of tabulated results upon Gabbett agitations as a type of the investigations. We may add a few remarks in conclusion. The acid process does not appear applicable to West Australian ore as typified by a sample of Oroya ore, where it appears necessary to dry crush and use a soap circuit; now has Mr. Cattermole been successful in granulating mineral from the highly complex Nagyag ores last obtained from Mr. Alexander Hill. These samples differ somewhat from those obtained by us in April and May from the Bergrath Steinhaus upon which, as already noted, good results were obtained. It is, however, very satisfactory to record the fact that the granulation of Broken Hill ore proceeds perfectly well in highly saline waters, made up by us to represent Western Australian water supplies, if .2% of acid be used in the circuit. We also enclose a tabular view of Cattermole and similar reactions, which were drawn up by us in July for the aid of counsel.

We are, dear Sir,

Yours faithfully,

SULMAN & PICARD.

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GABBETT AGITATIONS.

(N. B. Normal revolutions of cone about 1,000 per minute)

Ore.	Pulp Liq.	Emulsion.	Oleic Acid.	Time.	REMARKS.
400 grms. *of ½—½	400 c.c. of .2%	25 c.c. 33.3% P.emuli & soft soap.		5 mins.	Some separation Fines very dirty. POOR.
a²	agitated again.		1 c.c.	5 mins.	Great improvement but sands not clean some coarse galena free. FAIR.

*

e.)
½ 60 mesh)
½ 80 mesh)

Ore.	Pulp Liq.	Emulsion.	Oleic Acid.	Time.	REMARKS.
400 grms. ½—½		25 c.c. 33.3% & Oleicaad soap.		5 mins.	Slightly better than A.
B²	agitated again.		1 c.c.	5 mins.	Great improvement even better than a. In each case fine sands flocculent.
B³	Further agitation.		1 c.c.	5 mins.	*Immediate improvement* Sands fairly clean slight floct. fines less galena free.
400 grms. of ½—½	400 c.c. of .2%	25 c.c. 33.3% (as in B)	None but 10 c.c. of 10% ol. K. S. Neut. (oleicaad =(KHO neutral soap.)		IMMEDIATE GRANULATION. Sands fairly clean not quite so as B³.
400 grms. of ½—½	400 c.c. of .2%	25 c.c. 33.3% ol NaS (as in B.)	10 c.c. of 10% ol. NaS & Scc 20% acid to neut. free alkaline.	1 min. 2 " 5 "	Grann. fair, sands fairly clean. same) Sands still dirty and same) flocculent Better results therefore from C. experiment.
400 grms. of ½—½	400 c.c. tap water	Same as D.	Same as D.	5 mins.	Fine diffused gran. sands clean & scarcely floc. Fines doubtful as they may be taken up with granules.

(This expt. to see if acid could be added after the emulsion.)

Ore.	Pulp Liq.	Emulsion.	Oleic Acid.	Time.	REMARKS.
Further	agitation			5 mins.	same as above.
	made to .2% acid	further agitation		5 mins.	improvement but sands dirty & blendy.

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F. 400 grms. 400 c.c. of ½—½ .2% acid	(8 c.c. of paraffin (instead of (emulsion.)	mixture of with 10% ol acid. soap in	5 mins.	Results no good.
F2		added 10 c.c. of Neut. 10% ol NaS	5 mins.	Results greatly improved & fine sands fairly clean.
(Soap wanted in emulsion.)				
G. 400 grms. of ½—½ 400 c.c. .2% acid	15 c.c. 33.3% (ol. NaS) & 10 c.c. 10% ol. NaS		5 mins.	Result bad.
	Another 15 c.c. emulsions.			Result fair, only film.
G2 Further agitation	30 c.c.=5% on min.		5 mins.	Very fine granular sands not clean.
G3 Further agitation		10 c.c. of Neut. 10% ol NaS	5 mins.	*Greatly improved.*
	(This Expt. confirms F)			
H. 400 grms. 400 c.c. of ½—½ of .2% acid	16 c.c. of 50% R_1 P_2	20 c.c. of 10% neut. ol. NaS	5 mins.	No good.
H2 Further agitation			5 mins.	No good.
(This Experiment going back on old thick oil emulsion.)				
I. 800 grms 800 of ½—½ .2% acid	50 c.c. 33.3% P. SS emuls.	4 c.c. oleic acid.	5 mins.	This to see of any change takes place, agitation being different & pulp bulks same. Granulation only just commences compare with A.
I2 Further	2½ mins.	making 7½ mins.	7½ mins.	Begins to lighten.
I3 "		2½ mins. making	10 "	Granulation fair. Sands not quite clean. Showing that agitation is different.
	This Expt. only differs from A. in bulk of pulp used.)			
J 200 grms. 400 of ½—½ .2% acid.	12½ c.c. 33.3% P. S S emuls.	1 c.c.	5 mins.	Result poor.
	(Same as in A but only half proportion in relation to water.)		10 "	Same. This proves that although general conditions are same—more importance must be attached to to type of agitation.

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K. (Same rations as in A but double bulk.) 800 grms. 800 of 25 c.c. 33.3% P. SS 2 cc. ½—½ .2% acid. emuls.	8 "	Granulation hardly started.
K^2	10 c.c. neut. 10% ol NaS. at 14 mins.	Granulation appears to start.
K^3	17½ "	Fine diffuse of granulation.
CHANGED AGITATION To SLOW ROLLING for further	2 mins.	Excellent separation & granulation.

(Shows enormous effect of changing (slowing) agitation type.

Complainants' Exhibit Sulman & Picard Report November 19, 1903.

Received
20-11-03
Partially Ansd.
23-11-03

Sulman & Picard,
44 London Wall,
London, E. C.
Nov. 19th, 1903.

John Ballot Esq.,
Chairman,
Cattermole Ore Concentration Syndicate, Ltd.
607 Salisbury House, E. C.

Dear Sir.

We beg to report to you upon work done since the date of restarting the experimental plant on October 8th.

BROKEN HILL ORE, 3 sacks of ore were freshly crushed by Messrs. Johnson & Sons to 60 mesh.

Plant. This was cleaned up, new rubber joints being fitted to all pipes, and a new full-way tap to water feed.

The following defects were also remedied: iron pipes in sump removed owing to corrosion by acid and loss of latter. If found to be necessary they will be replaced by earthenware pipes. The spindle-bearings were re~~mov~~newed, but after short run, the wear being very apparent, it was decided to abandon the bottom bearing entirely. Gunmetal bearings above the cone were substituted, but the cutting action of the sands (garnet) toegther with electrolytic action between brass bearing and steel spindle so rapidly destroyed the latter that this method had to be abandoned. Brass spindles were obtained from Messrs. Still & Co. only the top bearings being retained in their entirety, but wooden blocks as rough guides were subsequently fixed below. So far this system has worked very well and is an important point gained in simplifying the larger plant.

The cone screw connections between the bearing shafts and spindles have now been soldered solid to the spindles, the former loose screw connection with india-rubber washers having given much trouble.

The exit pipe from the first series of mixers, into the first upcast, was found to be unsatisfactory when merely horizontal. It has been replaced by a bent tube, the top of the bend reaching the level of the top of the last cone. This change largely prevents blockage of the tube by ore, and acts as an air trap to a considerable extent.

3″ pulleys were obtained to be fitted (interchangeable

with existing 1½" pulleys) to mixers 5 & 6, in view of slower rolling having been found advisable for the completing of the "granulation" process on several occasions previously.

The Second upcast was increased in length to give a better separation and slightly increased in width. It was also fitted with a coned valve to aid in closer regulation of the downcast current. It was found also that if the delivery pipe from No. 6 mixer into the second upcast were permitted to dip below the surface of the liquor in the downcast tube of the latter, that much air was drawn down with the pulp which caused flotation loss of mineral in coarse sands. If the delivery tube be cut short exactly at top of upcast but little air difficulty is experienced.

Many other minor alterations made and defects remedied which need not be specified here, but of which note has been made for future application in regard to the larger plant.

The "10 ton" plant, (so-called, although until the first runs therein are made it is impossible to gauge, even approximately, its capacity per 24 hours), has been designed on lines shown by experience gained with the small plant to be the most desirable. 40 gallons earthenware pans with rounded bottoms are being specified as mixers, the number and disposition being the same as in the small plant, but with the addition of an-

other series of 3 for retreating the coarse sands if such should be found necessary.

The small duplicate of present plant on order from Messrs. Still & Co., for Mr. Courtney, is progressing somewhat slowly. The spindle and bearings are made, as also are the brass collars and connections for the mixers. The glasses are in course of cutting and fixing. Messrs. Still inform us that they hope to complete the plant in about 10 days from date.

Emulsion used in following trials: Owing to the colder weather the R_3P_1 type was found to become too thick to flow freely thro' the small taps used to regulate the emulsion additions and R^1P^1, 33% (=16½% Residuum & 16½% paraffine) with 3.3% soft soap and 63.7% water used. This emulsion was not quite so good a granulator for zinc blende slimes as the thicker, but had been previously found preferable for subsequent "breaking down" operations.

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BROKEN HILL GRADING TEST. (Ore crushed to 60 mesh)

+ 60 mesh	= 6.10%
— 60 + 80	= 17.35%
— 80 + 90	= 9.40%
— 90 + 120	= 11.00%
— 120 + 200	= 31.00%
— 200 (not actual "slimes")	10.00%
"Water-borne" slimes	= 15.15%
	100.00%

This contains an abnormal proportion of "fines" for fair 60 mesh crushing viz: 56% passing 120 mesh.

Original assay (Ref. No. 659)

Lead	= 18.56%
Zinc	= 16.21%
Insolubles	= 44.75%

Silver = 14 oz. 3 dwt 0 grs per ton.

In the first run 500 grms added to No. 1 mixer every 4 minutes and emulsion feed regulated to give about 4.0% of oil on mineral present.

Started in usual way by agitating 500 grms ore in mixers 1, 2, 3 & 4 each with required oil addition, thereafter continuously running via No. 1 mixer only.

During this run stoppages caused by choking of upcasts with consequent loss of mineral in tailings.

Including stoppages 23 lbs. ore put through in 90 minutes (= 10.500 grms.)

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Concentrates won	= 4900 grms	(47.6%)
Coarse sands	= 3705 "	
Fines sands	= 1690 "	
Loss (through choking, and remaining suspended in circuit)	= 205 "	
	10500 "	

Tailings Assay

Coarse sands.	Lead	=	8.86%
	Zinc	=	8.45%
Fine sands.	Lead	=	7.22%
	Zinc	=	6.10%
Concentrates. Insolubles			16.5 %
Lead recovery in concentrates			76.8 %
Zinc " "			75.6%

Slight loss of oil in tailings owing to percentage of oiled mineral carried by them.

The acid water circuit was 200 lbs (20 gallons) and before a run contained 0.24% H_2SO_4 after " " 0.16% "

Nagyag Tests.

A series of small trial tests was made on fresh ore supplied by Messrs. Alex. Hill & Stewart to ascertain whether this ore was amenable to Cattermole process. Mr. Cattermole made several trials previously, but ex-

Complainants' Exhibit—Sulman & Picard Report
November 19, 1903.

pressed doubt as to whether the ores would prove tractable to the process.

The main difficulty experienced was loss of acid by calcite and other carbonates—acid being neutralized before granulation effected. This was overcome by starting with'0.1% acid water making the addition of ore and emulsion, then adding another 0.1% acid after agitation for some little time. Good shotty granules were separated by handworked upcast, leaving very fairly clean sands. The granules retained their shape after drying.

The main difficulty of loss of acid due to calcite has still however to be faced and further work is required to ascertain whether neutral metallic salts, etc. can be used in place of acid. The soap circuit process (alkaline method) is inapplicable owing to the great destruction of soap by this particular ore.

The evolution of carbonic acid is also another great drawback, as mineral is floated up thereby; after standing (till liberation of CO_2 is complete), gentle rolling brings down and granulates the mineral, rendering it recoverable in an upcast.

Blinman Ore. (Rfer. Nos. 669a & 669d)

Average copper	=	5.58%
Calcite in sample A.	=	67.30%
Calcite " " D.	=	58.20%

This ore was mainly chalcopyrite disseminated through a calcite gangue. (Some of the copper was in

an oxidized condition (carbonate) in the gangue, and such of course would be irrecoverable by oil; nor could it be recovered by any other wet method or concentration known to us, or even by acid leaching methods owing to the excess of calcite. Ammoniacal liquors did not appear to withdraw the oxidized values from the tailings with any marked readiness.)

2000 grams were tried in large apparatus; ore mesh = 60 emulsion R^1P^1 (as before, addition being 5% oil on mineral. Acid circuit 0.1% H^2SO^4 at first agitation; after two minutes another 0.1% H_2SO_4 added; good granulation of coarse mineral obtained, but flocculation of slimes enclosing fine mineral particles occurred.

The gangue was floated off and the sands agitated further, both with and without oil; but the granulation was not sufficient to permit a sharp separation in the upcasts. The results of this first run were very poor.

Fines	76.5%	of original ore	= 3.22%	copper
Coarse	17.5%	" "	= 5.32%	"
Concentrates won	6%	" "	= 24.76%	"

The above test shows that upcast apparatus will require modification for various ores. Further work was suggested in this direction, and also as to the use of an alkaline circuit, but orders were received to proceed with Broken Hill work.

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Broken Hill trials resumed. (Ore No. 659)

Acid circuit 20 gallons; started at 0.24% at H_2SO_4

do after 2 days' trials 0.122% "

The object of this run was to see if it is necessary to retreat sands. Emulsion used, R_1P_1, oil = 4% on mineral. Test as before, 12 lbs. ore being used.

Concentrates won, 2470 grms = 40.3% original ore.

Owing to choking up of upcasts two bad periods of separation took place of 3 minutes each, giving undue proportion of sands in concentrates.

Concentrates won Insolubles = 20.5%

do oil (after drying at 100°C = 3.5%

The latter figure shows too slow a feed from emulsion tank.

The fines, and coarse sands, were then mixed and again put through the apparatus without further addition of emulsion.

The fine sands separated in No. 1 upcast now showed:

Zinc = 3.59%

Lead = 3.84%

Coarse sands separated in No. 2 showed:

Zinc = 5.94%

Lead = 4.38%

The Concentrates together with the coarse sands and fines were now mixed together and retreated through

the whole plant at the rate of 500 grms per 3½ minutes; emulsion added at the rate of 1cc. per minute, a total of 30cc. being added in all.

Final retreated products:

Coarse sands 1860 grms.

Assay: Lead = 3.84%
Zinc = 4.21%

Fines 940 grms.

Assay: Lead = 3.52%
Zinc = 2.97%

Recovered concentrates from tailings, 870 grms.

Insolubles	=	14.35%
Oil	=	4.60%

This conclusively shows the better retreatment products obtainable by addition of emulsion.

Summary of results.

Lead recovery	=	90.9%
Zinc "	=	89.4%
Total oil on concentrates	=	3.78%
Concentartes obtained	=	54.4%

Better extractions would be obtained,

(1) by making the feed from the hopper uniform and continuous instead of intermittent as at present,

Complainants' Exhibit—Sulman & Picard Report
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(2) more regular and more accurately quantified emulsion feed,

(3) return to R_3P_1 type of emulsions—which have consistently given better granulation than R_1P_1.

Amlwch Ore.

56 lbs. crushed to 60 mesh by Johnson & Sons.

Original assay:—

Zinc	=	18.06%
Lead	=	7.74%
Copper	=	1.7 %
Gold	=	0 oz. 1 dwts. 23 grs.
Silver	=	6 oz. 8 dwts. 5 grs.

Grading test.

Stays on 60	=	2.5%
— 60 + 90	=	25.0%
— 90 + 120	=	12.0%
— 120	=	60.5%

A preliminary run on this ore showed that granulation took place to some extent in 0.2% acid circuit, using 5% oil on an estimated contents of 40% mineral, but with the addition of a little oleic acid; emulsion = R_1P_1.

2000 grms ore taken; and 0.5% more emulsion added in mixers Nos. 5 & 6.

Concentrates won	=	22.5%
Insolubles	=	23.6%

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Larger Run. 22 lbs. ore used, in 90 minutes,

Circuit at start 0.2% $H_2\ SO_4$
Circuit at finish traces only.
Emulsion R_1P_1; = 5% on 40% mineral.

The usual routine was followed, after 5 minutes perliminary agitation, 500 grms of fresh ore being added to hopper feed every 5 minutes. Owing to the fineness of the ore the first upcast current was kept very slow, notwithstanding which large amounts of slime remained suspended in circuit and would not settle.

Most of the tailings were rejected in No. 1 upcast, but the concentrates and sands produced, although granulation was apparent, were but slightly removed from original ore.

Concentrates.	=	17.01%	
Insolubles	=	17.5 %	
Lead	=	7.84%	
Zinc	=	21.04%	Balance being slimes held in circuit.
Coarse tails	=	17.50%	
Zinc	=	17.20%	
Lead	=	6.88%	

Further trials are in progress.

We are, dear Sir,
Yours faithfully,
SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report, March 4th, 1904.

44, LONDON WALL, E. C. 4th March, 1904.

Received 5-3-04.

SULMAN & PICARD,

44, London Wall. E. C. 4th March, 1904.

John Ballot, Esq.,

Chairman of the Cattermole Ore Concentration Syndicate Ltd.

Dear Sir,

The work done since the date of our last report has been largely of a constructive nature, viz.: the erection, alternation, running and testing of the Cattermole oil (trial) plant for Mr. Courtney (The Sulphide Corporation Manager) at Cockle Creek.

This plant has been built to your orders under our supervision and with Mr. Cattermole's assent upon inspection, by Messrs. F. M. Still & Co. and has been erected and run at their works at Charles St Farrington Road.

This plant is now in efficient working order, tests having been made on Broken Hill ore "straight" therein, and is now to be taken apart, carefully numbered and lettered, and packed for despatch to Australia, Photographs of the plant have been taken, and copies of these will be numbered and lettered similarly, to aid in the re-erection of the plant in Australia.

This report will therefore deal mainly with the modi-

Complainants' Exhibit—Sulman & Picard Report
March 4, 1904.

fications made in the Courtney apparatus as found advisable after experience with the original type plant erected at 44 London Wall.

(1) The apparatus was similar in general design but the ore feed was improved; this followed on a series of ore-feed experiments undertaken at 44 London Wall, the hopper being provided with a mechanical stirrer operated by a worm wheel on the top shafting.

(2) Mixers employed: These were in three tiers, four being on the top row, three in the second, and two in the third; the last being for retreatment of coarse sands.

(3) The upcasts were made larger in capacity and were fitted one to each mixer tier.

(4) The cones in the last two mixers were driven from a second or counter shaft.

The details of the above plant are seen in the two photographs by W. Schuth, which are at the moment under duplication by Messrs. Vicars & Coy. Photos duly numbered and marked will be dispatched *with the plant* to Mr. Courtney.

With Broken Hill ore the new ore mixer permitted an even and easily regulated feed.

The new emulsion feed gave a sufficient flow without it being necessary to resort to air pressure; apparatus for this was, however, supplied in case of necessity.

The speed of the main shop shafting was 250 per minute and the speed of the fast (normal) cones, about 988 per minute.

Complainants' Exhibit—Sulman & Picard Report March 4, 1904.

Owing to the increased size of the upcast, made in deference to Mr. Cattermole's suggestion as to the limited capacity of those based upon the first or smaller plant, it was found necessary to enlarge all the circuit supply pipes and to obtain a larger return pump.

In the retreatment mixers if the speed was fairly high the pulp did not flow out sufficiently fast unless the baffles were so placed that one of the legs was placed just beside the outlet tube on the further side of the latter, in order to deflect pulp into the exit tube.

It was necessary to constantly regulate the emulsion feed, owing to the exceedingly variable temperatures of Messrs. Still's workshop in which the trial of the plant was carried out. This was due to the proximity of brazing furnaces and forge—intermittently used—to our apparatus. This lack of uniformity of conditions greatly militated against the obtaining of the best results and acted prejudicially against any long continued runs.

The general results have been, however, on the whole highly satisfactory, and some of the best products ever obtained by the Cattermole process have been secured.

The original assay of Broken Hill ore used in these runs was as follows:

Lead	19.52%
Zinc	16.69
Gold	traces
Silver	14 ozs. 11 dwts. 6 grains.

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The sample was ground by Messrs. Johnson & Sons to 60 mesh.

Run No. 1. (Monday, Jan. 25th, 1904.)
Ore used, 35 lbs. rate = 22.1 lbs. per hour.
Emulsion used, 33.3% R_3 P_1, 3.3% S. Soap solution:
Rate of flow at starting, 8.1 cc per minute.
do at finish 4.0 " "
Circuit at start = 0.24% H_2SO_4: 40 gallons in use.
do at finish = 0.19% " "
Therefore loss of acid = 0.05% = 0.2 lbs.

The run was started in the usual way with 500 grains of ore in each mixer, and the separations were good at first, but finished badly owing to the drop in the rate of emulsion feed.

Concentrates won 18.4%. This unsatisfactory result led to the rejection of concentrates and sands without assay.

Run No. 2. A slower pulley was fitted to ore feed. Ore used, 21 lbs. at rate of 14 lbs. per hour.

Emulsion used, same as before, but rate calculated to 4% on mineral present, i. e., assuming latter to be about 50%, but the oil feed fell off considerably soon after the start and had to be increased again towards end of run.

The run was carried out otherwise as usual, and the tailings retreated, but with no further addition of oil.

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March 4, 1904.

Concentrates won, 46%

Assay	Lead	26.7 %
	Zinc	22.31%

Retreatment concentrates from Tailings, 18.45%

Assay	Lead	18.69%
	Zinc	15.77%

Total concentrates, 64.45% very sandy

Recovery	Lead	80.4%
	Zinc	83.5%

The general of this run was therefore very poor, the concentrates being poor and containing much gangue. The variation, however, of the emulsion flow was great —being from 3 to 10 cc per minute. Another cause was due to the induction of air with mineral into upcasts. The various bends on the outflow pipes were altered several times until more satisfactory flows with a minimum of air inclusions were obtained; and it was decided that the granulation would be helped by the inclusion of more *fine* ore.

Run 3. (Independent of several small intermediate runs made to determine various factors in connection with the plant.)

Ore. 15% of ~~the~~ fine ground Broken Hill ore was added to the main bulk of 60 mesh material, and a further bend put into outlet No. 2.

Emulsion. Used as before, but with the addition of 1% of oleic acid. The ore put through was 25 lbs., at the rate of 14.2 lbs. per hour; the emulsion rate was 8 cc at first, afterwards dropping to 6 cc per minute. Total = 380 cc = 3.8% of oil on mineral.

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March 4, 1904.

Run started as usual by putting 500 grammes into each mixer, granulating this, and then opening continuous flow. No stoppages occurred during this run.

Flotation factor used.

The tailings were retreated as before, but on this occasion the coarse sands when passing through the last two mixers were allowed to be beaten well with *air,* by keeping the liquors *low* in the mixers and using fast agitation with baffles in. The concentrates were then found to be floated *up* in the upcast if only a gentle up current were used; the test thus started with granulation as usual, but the retreatment was partially affected by flotation. This was necessitated by the fact that flotation did occur to some extent in the first process, giving dirty sands which could not be completely cleaned by regranulating; the flotation cause of trouble was therefore used as its own remedy in the case of the last two retreatment mixer series.

Granulated concentrates won	= 41.4%	
Containing	12.8%	insolubles.
Retreatment concentrates	12.2%	
Containing	12.2%	insolubles.
Flotation concentrates	2.6%	
Containing	31.2%	insolubles.
Total concentrates won	56.2%	
Average insolubles	16.3%	

Fine tailings 26.8%

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March 4, 1904.

Assay

Lead	3.29%	of which 1.31% oxidised
Zinc	1.41	

Coarse tailings 17%

Assay

Lead	3.71	of which 0.48% oxidised
Zinc	2.71	

Note The oxidised lead present is probably as a protection covering over the other lead left behind.

Recoveries.

Zinc	94.3%
Lead	92.2

Run No. 4 (Mr. Keating present part of time).

In this run the products were not retreated, but the last two mixers were kept low and the last upcast used for flotation separation. Ore (as in last run) put through = 24 lbs. at rate of 14 lbs. per hr. Emulsion 33.3% R_3P_1 3.3% S. S., 0.5% oleic acid; rate = 3.8% of oil on mineral present.

Acidity of circuit before	0.23%
after	0.20%

Volume of circuit = 30 gallons = 300 lbs.
Loss of acid = 0.09 lbs. H_2SO_4 = 8.4 lbs. per ton of ore. This, however, was not due to ore entirely, as the

plain iron of the pump-plunger and one or two other iron connections were slowly attacked by the acid. This, will, of course, be easily remedied in a large scale plant.

Concentrates	(total)	54.6 %
	insolubles	22.75%

Note. Considerable trouble with emulsion feed during this run; but at one period a sample of concentrates taken before Mr. Keating and assayed showed only 10.5% insolubles.

Fine sands. 28.2%

Assay

Lead	4.64%
Zinc	1.54%

Coarse sands. 17.2 %

Lead	6.72
Zinc	6.12

Recovery

Lead	87.4%
Zinc	90.7

These results were therefore on straight products without any retreatment; and the bulk result would have been much better but for the serious fluctuations of temperature and therefore the difficulty of regulating emulsion flow.

A portion of the coarse sands from the last test was

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March 4, 1904.

retreated through the last two mixers with the addition of a little carbonate of lime.

The flotation concentrates obtained, 1.6%
contained 14.2% insolubles
and the coarse sands were reduced to

Zinc	3.44%
Lead	4.16%

Using these figures the corrected recoveries become

Concentrates won	=	56.2%
Lead recovery	=	87.8%
Zinc "	=	93.9%

Other tests followed on modified lines which will be reported under a different head.

We are, dear Sir,

Yours truly,

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report April 19, 1904.

SULMAN & PICARD,
44, London Wall, E. C.
19th April, 1904.

Received
20-4-04
Copy sent Mr. C. F. Courtney
and Mr. Chapman
April 22, 19~~1~~04.

John Ballot, Esq.,
Chairman, Minerals Separation, Ltd.,
607 Salisbury House, E. C.

Dear Sir,

We beg to hand you herewith record of work done since the date of our last report.

The following samples of oleic acid were obtained from Messrs. Charles Lamb & Co. of 60 Mark Lane, E. C., and analysed with the under mentioned results:

Oleic Acid (tin)	56.6% acid
Oleic Acid (bottle)	101.0 "
Distilled do	96.6 "
Saponification do	89.5 "
Red Oil.	38.9 "

A further sample obtained 14/3/04 = 101.1% acid.

The latter was that selected.

The reason for two samples of the above shewing over 100% of oleic acid is due to the presence of fatty acids

Complainants' Exhibit—Sulman & Picard Report
April 19, 1904.

of lower molecular wt. than that of pure oleic acid, which, when expressed as the latter, give a somewhat higher reading—just as Sodium cyanide expressed in terms of Potasium cyanide would show 132% of KCy.

A series of tests were made to demonstrate the recovery of oleic acid. Ore, water, and oleic acid were shaken together in the ordinary proportions, the weight of oleic acid used being carefully noted.

The top liquor was poured off from the granulated mass and found to contain no oleic acid, all having been carried down by the mineral. The latter was now treated by shaking with warm 2% caustic soda solution, the resulting soap liquor drained off, and the residue also washed with a little distilled water, the washings being added to the main liquor bulk; the mineral, etc., was left perfectly free from even traces of oil (oleic acid). The soap liquor was now neutralised with Sulphuric Acid, the oleic acid being turned out and floating to the surface. This was collected and quantified by titration with caustic soda standard solution 99.1% of the quantity of oleic acid originally taken being shewn to be recovered.

This operation was repeated twice on the same quantity of oleic acid with precisely similar results, showing that the recovery of this oil from mineral is practically speaking perfect.

The vanning experiments referred to in our last re-

port were now continued. We endeavored to obtain the loan of the small 8′ Wilfley vanner (now dismantled) formerly in use at the premises of Wilfley Co. in Old Jewry, but without success. We therefore instructed our carpenter to make a small model 3′x2′ table, which was done according to our designs.

A series of demonstrations were made on this table using "dirty sands" obtained both from old material derived from Mr. Courtney's plant at Charles St. and from ore freshly granulated in the repaired Cattermole plant in our laboratory. Acid circuits from 0.2% to 0.5% H_2SO_4 were used, the necessary carbonate of lime (in the form of whiting) being mixed with the sands just as they were placed on the table. The great bulk of the mineral was removed in large black flocks and floated over the riffles into the slime launder where it was collected; the sands and a very small quantity of residual mineral worked off in the ordinary manner at the further end of the vanner. The separations, though exceedingly good, were not perfect for the following reasons:

(1) the table—and especially the riffles—were not long enough in the very small model employed.

(2) the carbonate was too finely divided, giving off almost all its gas at first contact with the acid water and leaving none to be generated further along the travel.

(3) the riffles were rather too high to allow the only feebly floated mineral to be carried over.

The results however gave cleaner sands than we have

ever obtained by other means and justified the trying of the experiment on a larger scale.

This was done at the works of the Wilfley Co. at Lever St., City Road, upon freshly prepared "dirty sands" in the presence of Messrs. Ballot, Webster, Gregory, and ourselves. Owing to the shortness of the time at our disposal no proper arrangements could be made for a flow of acid circuit liquor on the 16′ table used; nor was any continuous ore feed possible. The material was therefore fed on by hand and dilute (1%) acid sprinkled on the ore (mixed with ½% of whiting) just as it began its travel. Under these conditions a continuous test was impossible, but the results intermittently obtained were quite sufficient to demonstrate that the principle of flotation vanning was the correct solution of the difficulty hitherto experienced in cleaning up dirty sands.

The following are assay results on some of the products obtained.

(1) Test made on the small model table, dirty sands being fed on continuously from No. 2 up-cast; 0.4% H_2SO_4 being the acidity of the circuit, and ½% whiting being added, as a *pulp,* to the issuing sands.

Concentrates	20.75%	Insolubles
Tailings	2.4 %	Lead
	2.9 %	Zinc

The difficulty here was, in absence of proper appliances (time being too short to install these) the due admixture of carbonate and sands. Still, however, the results are

Complainants' Exhibit—Sulman & Picard Report
April 19, 1904.

very fairly good, bearing in mind the fact that the sands were purposely very heavily loaded with mineral.

(2) Wilfley Test at Lever St.

(a) Large test

Concentrates	34.1%	Insolubles
Tailings	4.8%	Lead
	3.95	Zinc

In this test the difficulty experienced was in obtaining the uniform feed of acid; as before pointed out this was added by hand intermittently, and could only be applied at one part of the table. At the moments when the conditions were right the sands came off in absolutely clean lines, but when the deficit of acid occurred much mineral escaped into the tailings.

(b) A smaller test on the same table gave:

Concentrates.	Insolubles	25.75%
Tailings	Lead	0.70%
	Zinc	0.75%

In a properly arranged vanning plant the latter results could be made absolutely continuous in our opinion.

(We refer to the remarks made in the Working Instructions prepared by us, and forwarded to Mr. Courtney with regard to "shaking tables." We think these would answer even better than vanners of the Wilfley of Buss types. This can be tried by removing the riffles from your small model table and altering the motion from a longitudinal rocking motion to a sharp jerk or knock. The circuit water will be fed on as usual, but the

table will be only very slightly inclined towards the slime launder and less circuit water will be required.)

After the conclusion of these tests and after the Easter recess, the plant at our laboratory began to be dismantled for removal to Aldermanbury Avenue. We were also engaged for many days in preparing the full working instructions for Mr. Courtney above referred to, a copy of which we have supplied to you.

Mr. Chapman left on Friday last, the 15th inst., for Australia, fully instructed by us and yourselves.

During the period of the re-installing of the plant we are carrying out a series of trials as to the recovery of Hydro-carbon oil (emulsion) from the concentrates.

The concentrates contain as a rule from 3 to 5% of oil —say averaging 4%. When these are dried up from adhering water the oil is hardly apparent or visible, and they are almost crisp and granular to the touch.

From 3% oil residues nothing is extractable by pressure and the means adopted for recovery of the oil must be moderate in cost. 3% of oil on the concentrates is equivalent to say 1½% on the original ore; 1½% of oil = 33 lbs. per ton of ore, 4% of oil similarly = 44 lbs. per ton of original ore or almost 4½ gallons. Taking the cost of oil at £6 per ton in Australia, 44 lbs. = 2/4d. per ton of ore, if none is recovered. There is therefore only a small margin available for recovery costs. Further the petroleum residues (as found by Mr. Cattermole) are exceedingly difficult to remove with any degree of completeness from galena; in this respect they differ ma-

terially from paraffin oil, and as you will recall gave great difficulty in the breaking down process. We have tried very many experiments with soap solution, and soda caustic do, separately and mixed, from 1 to 10 % in strength, but in every case 1 to 1½% of oil has been left behind. Each 1% of oil represents 7d. per ton on the original ore.

We have tried the effect of heat with these re-emulsifying agents on oiled concentrates and find this advantageous. Steaming in a press might give good results but we have no available apparatus to determine this.

We are trying the effect of emulsifying solutions under pressure and temperature and will report same to you shortly.

Yours faithfully,
(Sgd) SULMAN & PICARD.

P. S. We beg to return Kendall's specification herewith. There is of course nothing that interferes with your patents therein.

We also draw your attention to Van Meter's Aluminated Hydro-carbon oil process, which is being advertised somewhat largely in South America. It is a flotation process of the Elmore type but with specialized apparatus. Van Meter's process is equally foreign to the patents held by you and we only mention it as putting our knowledge of the process on record with you. The better known oil processes (so far tried commercially) are

Robson's ; paraffin oil pumped through an ore pulp; now obsolete.

Complainants' Exhibit—Sulman & Picard Report
May 2, 1904.

Elmore; flotation by means of viscous hydrocarbon oils; also oiled belts and table apparatus.

Scammel; flotation by means of hydrocarbon oils thickened, etc., by means of Sulphur di-Chloride.

Kendall; flotation of graphite *only*, by paraffine.

Van Meter; flotation by means of thick hydrocarbons rendered more viscous by the employment of acid salts of alumina.

Owns the Everson patent.

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report
May 2, 1904.

SULMAN & PICARD,
44, London Wall, E. C.,
May 2nd 1904.

Received
4-5-04.
Board
18-5-04.

John Ballot Esq.,
Chairman, Minerals Separation Ltd.,
607, Salisbury House, E. C.

Dear Sir,

We beg to report on a trial experiment on the Cattermole process of granulation to determine the effect of temperature.

In the "Van Meter" process (pamphlet) i~~s~~t is stated that, with the particular oil used therein,—viz, heavy hydrocarbons thickened with said Alumina salts,—at a

temperature of 140°F, Zinc blende is not taken up. In order to ascertain whether this alleged fact would aid in the classification of Broken Hill ore by preventing the inclusion of the blende in the granules, a series of shaking tests was made at temperatures ranging between 50° & 90°C.

At the lower of these no marked difference was apparent, but when the temperature approached 80°C, it was evident that some mineral was escaping granulation. This from its colour appeared to contain more blende than before, and after two or three further trials the best apparent separation was passed through a small upcast apparatus.

The fines which floated off and the coarse material which fell were assayed with the following results:

Coarse:

Zinc	13.41%
Lead	11.58%

Fines

Zinc	19.87%
Lead	22.58%

No separation was therefore effected; indeed the finely divided galena had resisted granulation even more than the blende, although not indicated by colour.

Nevertheless the effect of increased temperatures in preventing granulation of fine mineral was so pronounced as to perhaps make it worth while to investigate the subject further.

Though inapplicable to the separation of Broken Hill

Complainants' Exhibit—Sulman & Picard Report
May 18, 1904.

ore minerals, we think you would do well to take note of heat effects generally, and at some future time to determine the various temperatures at which the more commonly occurring minerals, at a given mesh, refuse to take up oil from the same emulsion.

We are now carrying out a series of concentration tests on Nagyag ore, on the lines indicated in our conversation with you this afternoon.

We are, dear sir,

Yours faithfully,

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report May 18, 1904.

Received 18-5-04. SULMAN & PICARD,
Answered 24-5-04. 44, London Wall, E. C.
Board 18-5-04. 18th May 1904.
J. B.

Messrs. The Minerals Separation Ltd.,
607 Salisbury House, E. C.

Dear~~s~~ Sirs,

In answer to yours of the 16th inst., asking for a detailed report of work up to date, we are unable to give you, by this meeting, full details of the work done, as much of it is still in hand and will be more suitably dealt with in the course of a few days, certainly by the end of the month.

Kindly, therefore, regard the present as a short interim statement.

Complainants' Exhibit—Sulman & Picard Report
May 18, 1904.

PLANT AT ALDERMANBURY. This is in efficient working order and several runs have been made along the older lines, but with certain small modifications.

Firstly:—A different emulsion has been used, namely R_1P_1 plus 20% of Oleic acid. This results in giving clearer sands, and the oil is somewhat more readily recoverable from the concentrates. We have experimentally used such mixtures ourselves, but one objection to it was the difficulty we found on a small scale of recovering the oil in suitable emulsion form. Doubtless this difficulty could be overcome, and we are undertaking a series of experiments with the same, in accordance with your wish.

Hitherto therefore we have preferred to use either Hydrocarbon oils with an absolute minimum of Oleic acid, or else Fatty acids free from Hydrocarbon admixtures.

Secondly:—The other modification has been the driving of the 6th mixing vessel at lower speed, which is certainly a step in the right direction, so far as Broken Hill ores are concerned.

CLEAN UP OF DIRTY SANDS.

This work gives considerable promise of early success. As foreshadowed in our last, we have converted the small model vanning table into a "bumping" table, and have removed the riffles. By this means on small samples of dirty sands we have been able to clean up nearly all the contained oiled mineral, and to produce sharp clean sands without the use of any gas producing car-

P. 1078, L. 7, insert " following on suggestions from Mr. Cattermole " after " used "

bonate etc., thus effecting considerable economy both in acid and carbonate. Under these conditions mere contact of the oiled particles with air when exposed on the surface of the table is sufficient to ensure their flotation removal from the sands.

The representatives of Messrs. Anthony Gibbs, witnessed an exhibition run on the lines referred to in the three preceding paragraphs, and expressed themselves as pleased with the separations obtained.

MR. CHAPMAN.

We see the arrival of the S. S. "Oratava" at Adelaide was cabled on Monday last; Mr. Chapman is therefore (presumably) by now on the Central Broken Hill Mine.

NAGYAG ORE.

Having obtained in the consent of Mr. H. A. Whittaker to experiment on samples of this ore, which he had stored with us, we undertook a series of trials. These are at present incomplete, and we should like your instructions to continue them. We have dealt with the ore on the lines of preliminary water, concentration, separating coarse crushed material from the slimes and submitting the separated coarse to vanning, by means of a plaque. A very fairly sharp concentration of the coarse material into sharp mineral and clean sands was thus obtained, assays of which have been made and will be given in the complete summary of these tests. The slimes which contained high values in gold and silver, were submitted to oil concentration both by flotation and granulation. The first trials do not show a complete extraction of these slimes, but gave indications that a very close recovery is possible.

Complainants' Exhibit—Sulman & Picard Report
May 18, 1904.

In dealing with material of this nature we find that much depends upon the thickness of the slime pulps treated; if the pulps are too thick, which was the case in our first trials it is difficult to bring all the oiled mineral out, either by granulation or flotation, but by treating a more dilute pulp this objection is overcome. We have made many assays of the intermediate products obtained, which we propose to give in our complete report.

We take this opportunity of expressing our conviction that with the exception of Broken Hill ore, and occasional ores of this type, (that is, where the gangue and mineral are much of the same specific gravity) the legitimate sphere of any oil concentration process will more and more in future, be confined to the treatment of slimes. In other words preliminary water concentration must be used to the fullest extent to which it is available, and only such products as escape the action of water concentration should be submitted to the action of oil. There are many reasons for this which will at once be apparent to you: foremost amongst which are (1) The contamination of coarse material, either mineral or sands with oil, for which there is no need; secondly, the inutility of putting coarse material through plant demanding special attention, and thus diminishing the legitimate capacity of such plant, when such material can be dealt with in a simple and economical water plant.

The credit of making water concentration, thus, to a large extent applicable to ores which cannot be reduced by this means alone, will still belong to the oil process, whilst the economies are apparent.

Complainants' Exhibit—Sulman & Picard Report February 17, 1905.

We are dealing with Nagyag ores on these lines; and you will do well to devote therefore, considerable attention in the near future to the treatment of pure slimes.

Yours truly,

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report February 17, 1905.

Received 18-2-05.
Board 22-2-05.
J. B.

SULMAN & PICARD,
44, London Wall, E. C.
17th February 1905.

Messrs. Minerals Separation Ltd.,
62, London, Wall, E. C.

Dear Sirs,

We are in receipt of your letter of to-day with regard to Schwarz's patent No. 23906 of 1904, and have considered the documents sent in connection therewith by Messrs. Boult, Wade & Kilburn. We think you are quite safe, and that if desirable, any part of this patent which may be considered to infringe your rights can be stopped by reference to the existing patents which you have. We think, however, it is desirable that we should all see Messrs. Boult, Wade & Kilbourn's representative, Mr. Ballantyne, on this point and would therefore ask you to fix an appointment at your convenience.

We have lately been struck with the fact which is already known to your staff at Aldermanbury and else-

where, namely, the enormous aid to the oiling and granulation of minerals which is afforded by the increasing of temperature of the circuit. An ore that would barely granulate at a temperature of 12°C, with 3% Oleic acid will readily oil and granulate in about three or four minutes if the circuit be warmed to say blood heat. This can simply be effected by the use of a closed steam pipe or coil placed conveniently in one or more places in the circuit, or in the granulating vessel, and the slightly increased heating desirable can be thus very economically obtained. Not only is the operation more perfect with heat, but the capacity of the plant is enormously increased and we are inclined to contribute at least a portion of the excellent results obtained in the large tests in Australia to the higher temperatures prevailing there, compared with London. This point seems of such importance that you would do well to enquire of Messrs. Boult, Wade & Kilburn whether this is not worth protecting by patent; in any case we think you would do well to have a series of tests made to quantify the heat effect more accurately.

With regard to the clean up of dirty sands by other means than a table (more or less of the Wilfley type) fitted with air pressure jets. We have made a series of trials and small apparatus designed more or less on the principle of the hand plaque, which gives such excellent results upon the small scale. The first of these consists of a strip of linoleum about 3 ft. long and about 6 ins. wide; this was slightly dished into a very flat concave trough throughout its entire length, and placed at a

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slight angle, the lower part of the linoleum trough dipping into the water. A suitable water spray or fine jets were placed over the trough to give a downward wash, and a slot, sufficient to permit the intercepting of any sands passing down into it, was cut across the width of the trough just below its entry into the water. Under this slot a separate vessel immersed in the water was placed to catch the sands. The whole trough was capable of being given a slow rocking or tilting or jerking motion from side to side.

A portion of the dirty sands containing oiled mineral values was placed at the top of the inclined linoleum trough, and a gentle reciprocal rocking or jerking motion from side to side was given to it; the sands were rapidly cleaned, and washed down the centre of the trough continuously, as they were swayed from side to side, whilst the mineral was rapidly floated off into the current of the water running down the centre of the trough, and was thus carried over the slot into the water beyond this where it could be collected; the sands on the contrary were intercepted by the slot and collected separately. This apparatus gave remarkably good results, the sands separated being absolutely clean, but the difficulty was that the mineral "float" on reaching the water surface at the bottom had a tendency to be sunk again, just by the slot, and to be thus mixed again to some extent with the clean sands. With a little experiment this type of apparatus could no doubt be readily improved, and this difficulty overcome. The second type of this apparatus consisted in putting a second linoleum trough of

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rather greater width exactly under the first, and increasing the side rock of the apparatus to such an extent that the floating mineral was alternately carried over the opposite sides of the top trough and thus fell into the bottom, collecting trough, which was provided with a suitable receptacle to collect this; whilst the sands were sufficiently heavy *not* to be carried over the side of the top-trough but continued their downward travel to their own receptacle at the bottom of this. With one or two modifications this type of apparatus gives promise of excellent results; but we were unable by hand-rocking to get the motion so exactly uniform as to carry off all the floating mineral over the side of the launder without permitting the escape of any of the sands at the same time. No doubt with simple mechanical rocking apparatus this type of apparatus would answer well. A further type again of this consisted in having a perfectly flat upper strip of linoleum, protected on each side by a fillet of wood about ¼ inch in depth, thus forming an extremely shallow trough. Strips of wood ½ inch in depth and about 4/7ths of the width of the linoleum were tacked on to the latter from alternate sides with a slight downward angle. These fillets of wood acted as baffles, retarding the too rapid downward travel of the sands as the shallow trough was tilted from side to side. The ¼ inch fillet along each side of the linoleum was sufficiently deep to prevent the sand from being carried over it, but permitted the floating mineral readily to escape into the similarly inclined trough placed below it.

A fourth type of apparatus has also given excellent re-

sults. It consists in what may be termed a modified type of the Frue vanner. An endless india-rubber belt about two feet in length (with filleted sides to prevent the escape of material over these) was made to travel between its two stretching rollers at a slightly upward inclination. The belt was also capable of being given an alternating side shake or a similar rocking motion.

The dirty sands were fed in to the belt at a point about ¼ of its length above the bottom roller. Suitably disposed sprays or jets of water were placed at various distances above this sufficient to give a very slight and gentle downward current of water over the belt. In this way the mineral was floated and washed continually downwards into a receptacle placed beneath the bottom roller whilst the sands were constantly removed upwards by the motion of the belt and were taken off quite clean at the top of the belt as this passed over the top roller. A very slight inclination of the belt is necessary in order to prevent the fine sands from being washed downward with the slight water current.

These few details will be sufficient for anybody with mechanical knowledge and facilities to design one or more working apparatuses which will have a large capacity of output and will be simpler in construction perhaps, than the air blowing table which is at present the only apparatus in use for your purpose.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

Complainants' Exhibit Sulman & Picard Report February 21, 1905.

SULMAN & PICARD.

Received 21-2-05. 44, London Wall,
Board 22-2-05. E. C. 21st February, 1905.
J. B.

John Ballot, Esq.,
Minerals Separation, Ltd.,
62 London Wall, E. C.

Dear Sir,

We beg to report the results of analysis of sample of "fine" dirty sands from Aldermanbury Avenue, which were obtained from the Oleic acid run a short time ago.

The sample contained 11.84% lead, and 13.39% zinc; Oleic acid 0.51% iron present as Oleate (and therefore soluble in Ether) = 0.037% equivalent to 0.408% *of iron soap,* which is again equivalent to about 0.36% of *combined* Oleic acid. This analysis is instructive, showing that the dirty sands contained over one-third of their Oleic acid as iron soap. This is a curdy, sticky, substance, and doubtless it sweeps together into flocky masses, oiled mineral, and oil, together with gangue. We have noticed previously that, in the insoluble form, soaps do certainly tend to adhere to gangue. It is worthy of note that no lime soaps were found in the above sample.

It is rather too early to definitely sum up the full advantages or disadvantages of iron soaps, but these bodies appear to us to give rise to the following difficulties.

(1) They tend to grease gangue as well as mineral.

Complainants' Exhibit—Sulman & Picard Report February 21, 1905.

(2) They are highly contractile and curdy bodies; i. e., when produced in dilute solutions they tend to shrink together into small curds or clots which may thus contain gangue, mineral, air bubbles, oil globules, etc., etc. It is highly probable that at least some of the loose flocks noticed may have a basis of iron soap.

(3) Loss of Oleic acid in the fine sands which contain iron soaps. It will be necessary for us to see whether iron soaps once formed can be broken up by treatment with dilute acid or alkali, for the recovery of their contained fatty acid. It would also be interesting to see whether the oiled concentrates also contained insoluble iron soaps. We had a consultation yesterday with Messrs. Leechman & Higgins, and pending the institution of the instruction book have decided upon the following programme for immediate purposes.

(1) Mr. Leechman will make two tests with alkali and water on straight Broken Hill ore, using triangular separating pieces of wood fixed upon the end of the Wilfley table in order to get the sharpest separation of vanned products. We propose only to use only the smallest quantity of ore that is capable of giving a definite result on the Wilfley table in each case; say 15 to 20 lbs.

We also propose to repeat these trials two or three times in order to ascertain whether the separations can be judged sufficiently closely to ensure consistent results,

and thus to afford reliable indications as to the value of alkali versus ordinary water in vanning.

(2) Mr. Higgins will carry out a series of a few small Gabbett runs in order to determine the best combined time and temperature factor for Brokn Hill ore used with straight Oleic acid.

We will select with him the most generally suitable factor resulting from the foregoing, and this will then be applied in the large plant in two runs, (a) run on 40 lbs. b with the plant as arranged at present (b) run on a similar amount but with a fresh fine sand's upcast used only after the last of the series of Gabbetts. From the information thus derived we ought then to be able to make a standard run, on 1-cwt. or 2 of ore.

We may recall that since the last run of this kind proved unsatisfactory, the following improvements or alterations in the general process have resulted: (1) The discarding of emulsions of Oleic acid, and the use of the acid direct, thus permitting a uniform and easily regulated oil addition. (2) The locating of iron soaps, and the presence of considerable quantities of this in the dirty fine sands. (3) The method of protecting metal surfaces which we have worked out (and are still working at) in order to prevent the destruction of the apparatus and the formation of insoluble metallic soaps whilst (4) the question of temperature forces itself upon us as likely to have a controlling influence on the question of output.

(5) The proposal to use only 1 upcast at the end of the complete series of Gabbett's which will permit of a much

longer clean-up period for the fine sands. These sands were very dirty in the last long run and all oil and metal values contained by them is *entirely lost* at present. In a series of over a dozen experimental runs which we have lately made in our laboratory we have proved that with small amounts of Oleic acid the fine sands and slimes can be absolutely cleaned from mineral, provided sufficient agitation be allowed. This fact, therefore, strongly supports the modification of the apparatus as proposed, namely, one upcast only (for the separation of the fine sands), and the employment of this only after the full agitation period of which the plant is capable.

We are therefore much better prepared for our next run than was the case when the previous attempt at a standard run showed the necessity for the foregoing improvements.

We return herewith Mr. Higgins' report to you bearing yesterday's date, and with much of it we are in complete accord; but we do *not* consider it at all advisable at the present moment to go back to the use of cheaper oils for granulation, as this means the re-opening of the question of oil removal and breaking down on which so much fruitless work has been done in the past. It is proved that with oleic acid very much smaller quantities of fatty substance can be used than is the case with R_3P^1 and similar oils, that 80% of the oleic acid can be readily recovered (which is not the case with residual oils); and therefore the economical difference between the two types of oils is not sufficiently large to make it desirable to forego the advantages which Oleic acid offers in re-

Complainants' Exhibit—Sulman & Picard Report
February 21, 1905.

gard to its recovery from the mineral, and therefore in breakdown. So much has to be done before even the Oleic acid process can be considered complete, that it would be quite a wrong policy to go back into all the troubles necessitated by the use of insoluble oils before finally completing a process which is thoroughly economical and efficient.

When this portion of your work is concluded then by all means reconsider afresh the old breakdown process, but we strongly advise against the latter for the present.

With regard to Mr. Higgins' remarks as to the use of oil process initially as versus water concentration by Wilfley of jigs, etc., this of course goes without saying. But no one is likely to ask you to concentrate an ore by oil which he can treat with commercial success by simple vanning, etc., as indeed is the case with so many lead-zinc ores, as you are aware. In the ore which Mr. Higgins examined initial water concentration would doubtless save the bulk of the lead, but heavy copper losses would certainly result.

As we have many times pointed out to you, you by no means preclude yourselves (in using your process) from the employment of previous water concentration, and would doubtless use or devise a combination of the processes according to circumstances. We only refer to this point again as Mr. Higgins in his report seems to unduly labour the matter.

We should like Mr. Leechman, as soon as he has finished the alkali vanning test, to fix up the small centrifugal pump we left at your office. This apparatus, we

think, will approach more nearly to the beating action of a shaking test than does the present Gabbett.

Finally we have advised Mr. Higgins as the next point of importance, on which attention ought to be centred (before *any* further work on cheaper oils is attempted) is the treatment of ores containing carbonates as typified by Nagyag and Blinman ores; (also Leroy ores). We have had some preliminary talk on this matter and will advise you as to further progress.

We think this exhausts most of the suggested work put forward up to the present, and propose you would be good enough to let Mr. A. O. Williams write up the necessary precis as to this (contained in this and previous reports) in the triplicate instruction book.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

Complainants' Exhibit Higgins Report March 2, 1905.

Copies sent

C. F. Courtney &

Geo. A. Chapman. 3/3/05.

Received 3/3/05.

Report on the Conditions of Granulation. March 2nd '05. Preceding work having proved that the temperature at which granulation is effected has a great influence on the duration of agitation required, instructions were re-

ceived from Mr. Sulman to determine the rate of charge of granulation with temperature. During these experiments the influence of other conditions was sufficiently marked to suggest to me their importance in altering the time of granulation, and these conditions have been carefully examined.

The Influence of Acidity. Our experiments here confirm those of Mr. Chapman in Australia, viz. that an increase of acid in the circuit causes a decrease in the time required for granulation. There is only one slight objection~~tion~~, which becomes noticeable when the solution is heated, viz., a slight evolution of sulphuretted hydrogen due to the solution of the sulphides. The iron pyrites may be the delinquent, which would account for the large percentage of iron in the circuit, reported a short time ago.

It will be seen from the curves that the influence of acid is much greater at lower temperatures than at higher.

Influence of heat. An increase in the temperature of the solution causes a decrease in the time of granulation. This is very marked, from a temperature of 8 or 10°C to about 40°C when an increase of temperature does not cause a very great decrease of time. The effect is startling when the former are compared with the latter. The curves below 10°C are not at all reliable since the time required for treatment was so long that the temperature had risen to air temperature at the end of the experiments. Two curves are also plotted showing the de-

crease in time with increase of temperature when ferrous sulphate contaminates the circuit. Below a temperature of about 23°C the ferrous sulphate causes an increase in the time of granulation but above that, it appears to decrease the time. These red curves, however, are not to be depended on so much as the black ones, and the differences in their slopes may be due to alteration in the speed of the cones, also to inaccuracy caused by a slight difference of temperature in the four mixers.

Experiments. Granulation in the 6 mixer plant with 1% and 0.49% acid contaminated with ferrous sulphate. Oil used 1.5% oleic acid on ore.

Temp: of Solution.	Time required to granulate.	Acidity
17°C	19 min.	1%
17°C	17 "	"
21°C	13 "	"
24°C	6½ "	"
28°C	5 "	"
29°C	3 "	"
19°C—20°C	28 min.	½%
23 —24°C	18 "	"
29 —28°C	12 "	"

These results are plotted in red on sheet I.

The second series of experiments were carried out in the single Gabbet of the same size and construction as those in the 6 mixer plant. Acidity of solution used i. e. tap water with 1%, ½% and ¼% acid as indicated.

Complainants' Exhibit—Higgins Report
March 2, 1905.

Oleic acid 1.5% on ore. Quantity of water 1500 c. c. Quantity of ore 500 gms. (in all cases Broken Hill 60 mesh). Speed of cone 900 revolutions per minute.

Time in minutes required for granulation	Temp: of contents of Gabbet at start of agitation	Acidity of water.
2½	46.5°C	1%
2¼	39 "	"
4	28 "	"
7½	20 "	"
11	10 "	"
32	5 at the start	
	9.5°C at finish	"
3¼	53°C	½%
6	35.5°C	"
7½	24 "	"
11	10 "	"
20	2.5 at start	
33	8°C at finish	"
4	57.5°C	0.25%
8	36 "	"
12	31 "	"
22	17 "	"
30	11 "	"
35	2°C at start	
	7.5°C at finish	"

Complainants' Exhibit—Higgins Report March 2, 1905.

The oleic acid which we are using begins to solidify at 12°C and continues so doing until O°C is reached when it is almost solid. Obviously a solid oil is not capable of oiling a surface. Thus granulation cannot be expected when the temperature of the solution falls below the solidifying point and this fact may explain the great length of time required at low temperature.

Influence of the thickness of the pulp.

Starting with a thick pulp i. e. 1 of ore to 1 of water, the time of granulation is long and decreases as the proportion of water to ore increases, but, between 2 and 3 of water to 1 of ore the rate of change makes a great alteration and after the latter proportion becomes nearly constant at all proportions of water.

Experiments. Acid Tap water, ore, oleic acid, &c., as in last series.

Water	Ore	Time in minutes.	Temperature	Acid.
1000 c	1000 gms	20 not finished	29°C	1%
1500 cc	1000 "	16	30°C	"
1500 cc	750 "	7	30°C	"
1500 cc	500 "	5	30°C	"
1500 cc	250 "	4½	30°C	"
1500 cc	100 "	4	30°C	"

Results plotted in black curve on sheet II.

Complainants' Exhibit—Higgins Report
March 2, 1905.

Influence of Peripheral velocity of cone. An increase in the peripheral velocity of the cone causes a decrease in the time required for granulation, a point being reached after which this decrease is slight. Further experiments are to be carried out on this subject to determine the influence of friction of the sides of the Gabbett on the peripheral velocity of the cone. The speeds should also be taken still lower.

Revolution per minute.	Peripheral velocity in feet per minute.	Temp.	Time		Remarks
1100	1008	13°C	12	min.	
1430	1310	12.5°C	10	"	
860	788	12°C	16	"	
840	780	27°C	4½	"	
1075	985	26°C	4½	"	
1070-945	....	27°C	5	"	speed retarded
570	522	28.5°C	7½	"	neglected.
1462-900	....	26°C	10	"	do neglected.
1462	1337	27.5°C	4	"	
1462	1337	26°C	4	"	

Acidity 1%, ore 500 gms, water 1500 gms, oleic acid 1.5% on ore. Results plotted in red on sheet II.

There is one thing to be noted in all these experiments, viz, that the point at which granulation is complete is arbitrary and has to be judged by the appearance of the

gabbett contents, this can be done by practice but is not exactly a perfect method.

Experiments are also to be carried out on the influence of the quantity of oil present in order to complete the information regarding granulation.

Instructions have been received from Mr. Sulman regarding the influence of the size of the mineral.

A. HOWARD HIGGINS.

Complainants' Exhibit, Minerals Separation, Letter March 3, 1905.

MINERALS SEPARATION, Limited,

62 London Wall,

London, E. C., March 3rd, 1905.

H. L. Sulman, Esq.,

Dear Sir:

As requested I send you enclosed Mr. Higgins' Report dated 2nd inst. The diagrams referred to therein have not yet come to hand, but I will at once forward to you on receipt. I am, dear sir,

Yours truly,

A. O. WILLIAMS,

Secretary.

Complainants' Exhibit, Sulman & Picard Report March 3, 1905.

SULMAN & PICARD,

44 London Wall, E. C.

3d March, 1905.

Copies sent C. F. Courtney
Geo. A. Chapman 3-3-05.—
Received 3-3-05.
Board 19-4-05.
J. B.

John Ballot, Esq.,
Minerals Separation, Ltd.,
62 London Wall, E. C.

Dear Sir:

I beg to acknowledge receipt of copy of Mr. Higgins' report from you this day together with curve diagrams, both of which are returned herewith.

I am in full agreement with Mr. Higgins' report, only a few remarks being called for.

Page 1. *Influence of Acidity.*

We do not think that the iron pyrites is responsible for the production of sulphuretted hydrogen on being heated with 1% acid, so much as is the ferruginous blende. The formation of H_2S bubbles in this way, is, of course, the basis of the Potter and Delprat processes for separation of blende, and experience has shown us that ferruginous blende is more readily attacked by hot dilute acid than is pure blende. The large percentage of iron in the circuit

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liquors noticed of late is more probably due to the action of an acid upon cast iron surfaces exposed to the acid circuit.

Page 2. The curves showing the effect of ferrous sulphate as aiding granulation in warm solutions, but retarding the same in cool solutions (as compared with circuit liquor free from ferrous salts) is most instructive, and should be examined more closely hereafter; the effect of calcium soaps also requires investigation. In writing to Mr. Chapman we would be glad if you would forward to him paragraphs in our recent reports bearing upon the question of iron soaps. Whilst they may aid in granulation we do not think that such aid may be of unmixed benefit. Whilst we are not certain of the point, it appears to be likely that these iron and other metallic soaps are responsible for a considerable proportion of the "flocks" noticed, and therefore for the production of dirty fine sands, as see our last report.

We are in full agreement with the rest of Mr. Higgins' observations, and may summarize the work now being done at Aldermanbury Avenue as the determination of the following factors.

(1) Influence of acidity on granulation,
(2) " of temperature on granulation,
(3) " of speed of Gabbett agitation on granution,
(4) " of ratio of ore to liquor on granulation,

(5) " of metallic salts on granulation,
(6) " of the size of particles and of the influence of slimes on granulation,
(7) " of the amount of oil on granulation.

The above factors are being determined on

(a) Oleic acid,
(b) Residuum oils.

Mr. Higgins' present report is therefore the first instalment of the above scheme of trials. *The influence of the speed and type of agitator* becomes a factor of great importance according to our recent experiments. Speeds of rotation (with a small Gabbett) varying from 3 to 500 revolutions per minute proved almost useless. We then made a series of baffles which were placed in the Gabbett and which were solid," i. e., they occupied the greater free space of the Gabbett vessel from the glass sides up nearly to the working surface of the cone. They were found to be disadvantageous as they gave too violent agitation, and set up large eddy currents in front of each baffle, greatly reducing rotation speed of the liquor in the Gabbett and adding water friction to such an extent to the rotating cone, that the power required to drive the latter was more than doubled. On replacing these solid baffles by the ordinary type of thin rod baffles, the granulation period was much improved, and the power consumed in driving the cone fell again to the normal. *The number of revolutions* made by the rotating cone shaft

Complainants' Exhibit—Sulman & Picard Report March 3, 1905.

mean nothing apart from the average diameter of the cone. Hence all cone revolutions should be reduced to *peripheral* cone speeds, expressed in velocity in feet per minute, as has been done by Mr. Higgins. The importance of this will be manifest to Mr. Chapman in putting up the larger cones at Broken Hill.

We have also carried out a series of experiments with a small centrifugal pump in place of a Gabbett, to determine whether this gives a better form of agitation than the cone. Fearing the cutting effect of sharp sands on the blades of the centrifugal pump, Broken Hill ore which had been passed through a 120 mesh sieve was used.

The following figures were obtained by Mr. Leechman yesterday in comparison with the Gabbett, and show the latter to be distinctly preferable to the centrifugal pump, so far. In fact the figures are so conclusive that for the present we do not intend to continue centrifugal pump experiments. We may mention the centrifugal pump used was only a small one having about a 4½ to 5″ chamber but it was speeded up to about 1,200 revolutions per min. The pump therefore had a considerably higher peripheral speed than the Gabbett used in parallel tests.

Complainants' Exhibit—Sulman & Picard Report
March 3, 1905.

	Ore used B. H. 120	Temp. °C	% Acid	% Oleic acid on ore	Minutes	Remarks
(1)	Bell jar & centrifugals	10°	.4%	1½	60	Slimes not properly cleaned.
(2)	Gabbett	10	.4	1½	15	Rather farther than (1).
(3)	Bell jar & centrifugal	50	.58	1½	9	Small granules.
(4)	Gabbett	50	.58	1½	2	Well cleaned.
(5)	Funnel & centrifugal	10	.4	1½	60	Unsatisfactory.

A series of tests were made on straight 60 mesh Broken Hill ore on the Wilfley table (in continuation of the hand-panning trials previously reported to you) in order to determine the difference between 1% caustic alkali and water in obtaining better separation on the table.

Three separate tests were made, under precisely similar conditions in order to eliminate errors of observation. Mr. Leechman carried out these trials and the "heads" selected in each case was that product which so far as could be optically judged was free from blende. The "cut" thus made between the products was not such as would be made in practice where more of the *middling* products would undoubtedly be included in the *heads;* but the comparative effects of plain water and alkali were able to be read more closely by this means. The following table (which is not yet quite complete, as it lacks the weight of tailings obtained in runs *two and three*) certainly shows a distinct line of favor of the alkali in

increasing the amount of sharp lead products at the expense of the middlings. It is too early yet, however, to base any economical argument upon these results, as the collected products require to be assayed in order to arrive at the amount of the respective metal saving effected in each case by water or alkali. The table will be completed in our next report.

	Alkali 1.	Water 1.	Alkali 2.	Water 2.	Alkali 3.	Water 3.	Total Alkali	Total Water
Heads	2.1	1.9	2.	1.8	2.4	2.2	6.5	5.9
Mids	5.3	5.5	4.	5.3	5.1	5.7		
Tails	10.5	9.75						

We have also devoted considerable attention to the treatment of *Nagyag slimes and fine ores* as this is a peculiarly difficult product to deal with, from the complexity of its mineral contents, the necessity which exists for recovering values (gold telluride) from the finest of its slimes, and thirdly, from the presence of such large amounts of calcite and soluble mineral products as to preclude entirely the use of an acid circuit, whilst the alkali process is almost equally inapplicable by reason of the immediate precipitation and flocculation of slimes on the addition of either soap or alkali. If Nagyag ore can be treated by oil any way such ores as Blinman, Le Roi, etc., will be easily solved by similar means.

In the case of Nagyag ore we found it impossible to oil the fine mineral sands in presence of suspended slime products. This was very marked even when minus 150

mesh material was used for the trials. On standing for a short time the pulps of such materials deposited marked amounts of fine pyritic and mineralised sands entirely unoiled, although varying large quantities of oleic acid or residuum had been originally added to the pulp, and violent agitation given.

We afterwards proved that this difficulty of oiling fine mineral was not due in any way to presumed slight oxidization of the mineral, and it became increasingly obvious that the finest (more or less slightly flocculent) slimes were taking up *all* the oil added to the pulp, and indeed acting as "interceptors" between the oil and the other fine material.

So marked was this effect that it has suggested to us the possibility that *highly divided material,* whether mineral, gangue, or oxide, has a tendency to oil, independent of the varying preferential tendency to become oiled that the larger particles or sands exhibit.

This fact has been noticed by us before in the treatment of fine Broken Hill slimes, in the small Gabbett, previously referred to. With the insufficient rotation speeds of the cone it was noticed, time after time, that whereas the coarse mineral refused to oil, and no separation of coarse mineral from sands was effected (i. e., no granulation effect of any kind was produced), the finest slimes had nevertheless cleaned up; thus showing in Broken Hills ore that the first tendency of the oil under these conditions is to com-

bine with the finest mineral rather than with the coarser. These trials have indicated to us the necessity for determining the effect of the *fineness of the particles on granulation* time and to suggest the possibility and even advisability, of submitting refractory slime and fine products to careful water classification before oiling. In the case of the Nagyag slimes we find that from 50 to 70% of material may be separated out, in a series of spitzkasten, from a pulp originally containing a material no coarser than 150 mesh. The very fine, but still sharp sands, thus separated by gravity, in a plain water circuit, are found to be capable of as immediate and easy oiling as the coarse sands, when once the most flocculent and obstinate slimes have been removed from them.

In the case of Blinman and Le Roi ores these finest slimes which hinder granulation would probably be so small in amount, or in contained values, that they could be rejected. But with Nagyag ores the finest slimes (containing substantial gold values) require treatment; and this appears possible by using a combination of the float and soap process, i. e., by what is generally known as the Froment process. A sufficiency of soap is added to the slimes to agglomerate them completely, and they are well agitated to insure their completest intermixture, then a small quantity of acid is well stirred in, and the usual "float" (derived from oiled mineral buoyed up with carbonic acid gas bubbles) results, and can be skimmed off.

Complainants' Exhibit—Sulman & Picard Report
March 3, 1905.

We have also tried the effect of agitating carbonated ore slimes with tar (wood and coal) with previously oiled galena concentrates, with wood dust, cork dust, etc., previously moistened with oleic acid, etc., but have not obtained such promising results as by (a) submitting the slime pulps to close spitzkasten classification, and treating the separated fine sands in the usual way and (b) treating the fine reject slimes by soap and bubble flotation.

In our next report we shall deal with the results obtained.

We are, dear sir,

Yours truly,

SULMAN & PICARD.

Complainants' Exhibit Mineral Separation Letter March 6, 1905.

MINERALS SEPARATION, Limited,
62 London Wall,
Nos. 413/415.

London, E. C., March 6th, 1905.

Messrs. Sulman & Picard,
44, London Wall, E. C.

Dear Sirs:

Enclosed I send you copies of Mr. Higgins' Report of 2nd inst., and yours of 3rd inst., together with original reports. I have gone through the copies, but think it best to send the originals to you so that you may have an opportunity of checking the two. Kindly return the originals as soon as you have finished with them and oblige,

Yours truly,

A. O. WILLIAMS,
Secretary.

Complainants' Exhibit Higgins Report, March 16, 1905.

Copies sent C. F. C. & J. A. C.
17/3/05.
Copy sent S & P 6/4/05.
Received 17-3-05.

Further Report on the Conditions of Granulation March 16th, '05. Influence of the percentage of oil.

The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth. 6% of oleic acid on the *mineral* is sufficient to form good granules without much froth. This froth consists of insufficiently oiled mineral mixed with large quantities of air. As this percentage of oleic acid is decreased, the time for clean up of the sands is increased and more froth is formed. 0.62% oleic acid on the mineral is insufficient to form any granules and nearly the whole of the mineral comes to the surface, on stopping the cone, as froth. 0.2% acts in the same manner leaving the coarse sands with rather more mineral in them. (This is 0.1% on Broken Hill *Ore.*) In all cases the oil has been measured in cubic centimeters and the percentage calculated as though they weighed grams but as the specific gravity of the oleic acid is less than unity this is not the case and, all percentages will be lower than those actually given.

Complainants' Exhibit—Higgins Report
March 16, 1905.

etails of Experiments.

cid	Oleic Acid	% of Oleic	Time	Temp.	Remarks
1%	15cc	3% on ore	4 min	30.5° C.	Very little float.
"	7½cc.	1.5% " "	4¼ "	31 "	Rather more float.
"	5.2cc.	1.04% " "	6 "	31 "	Still more float.
"	3.1cc.	0.62% " "	6 "	32 "	
"	1.6cc	0.32% " "	7 "	31 "	Float vastly increased.
"	0.5cc.	0.10% " "	8 "	31 "	Float vastly increased.
"	0.5cc.	0.1% " "	4¾ "	29° "	Not finished.
"	0.4cc.	0.8% " "	6½ "	30.5° "	
"	0.5cc.	0.1% " "	8 "	31° "	
"	0.5cc.	0.1% " "	8 "	31° "	Weight of concs. 170 gms.
"	0.2 cc.	0.04% " "	8 "	32° "	Apparently not much different.
"	0.1cc.	0.002% " "	12 "	32° "	Little worse.
"	none	none	7 "	32° "	Very little float.
"	none	none	10 "	32° "	More froth.

The froth in the last case was found to be due to some concen-
ates sticking inside the Gabbet cone from previous experiments.

Oil	Time	Acid	Temp.	Wt. of Float	Remarks.
one	(8)m (16)"	1.1%	32° C.	—	No~~t~~ froth only slime
one	16 "	1.1%	32° C.	—	ditto
2cc. eic	5½ "	1.1%	31° C.	—	Some galena unoiled.
one	10 "	0.877%	31.5° C.	1.102 gms.	For assay.
cc. oleic	12 "	"	31° C.	203 gms.	—
cc. alkhany	12 "	"	32° C.	—	Very little float
cc. ditto	12 "	"	32° C.	—	ditto.
cc. "	10 "	"	32° C.	—	Very little float, small granules
cc. "	5 "	"	46° C.	—	Less float

Complainants' Exhibit—Higgins Report
March 16, 1905.

.5cc. paraffine increased to 1% in stages	15 " 18 "		"	40° C.	—	Very little float. Sands not quite cleaned with the increase of oil.
.5cc. oleic	10 "	(distilled (water	.877%	32° C.	—	Apparently not different.
		Tap water				
.5 gm. tallow	15 "		.877%	40° C.	—	No clean up
1.5 gm. "	15 "		do	41° C.	—	Very little granln.
.5cc. oleic	10 "		do	31° C.	—	For assay of fine sands.

The quantities used in above expts. were Ore 500 gms. water 1500 cc.

The products from the last experiment were:

Froth concentrates 242 gms.

Fine sands 55 "

Coarse sands 198 "

The coarse sands were cleaned on the placque by aeration giving:

Clean coarse sands 167 gms.

Concs. from coarse sands 31 gms.

Allowing for 10% insolubles in the concentrates by froth, the concentration in that product is about 87%.

Assay of fine sands: 11% of ore treated.

Zinc	6.49%
Lead	12.64%
Insols.	61.35%
Silver	8 ozs. 16 dwts, 10 grs.

Giving a total concentration of—

Lead 92% Zinc 94%

Complainants' Exhibit—Higgins Report
March 16, 1905.

The assay of froth concentrates from a previous experiment, weighing 170 gms. returned

Zinc	32.70%		
Lead	28.75%		
Insolubles	12.10%		
Concentration		Lead	56%
		Zinc	69%

The froth was separated by stopping the cone removing it and the baffle from the Gabbet, allowing the sands to settle for about 3 minutes then inserting a funnel so that it dipped into the clear liquid, and pouring more water in, until the whole of the froth was floated over the sides of the Gabbet into a bowl placed underneath for that purpose. This also floated over some fine gangue which may account for the large percentage of insolubles in the concentrates.

Experiments on the separation of the froth are being made but so far no satisfactory method has been obtained.

A diminution of the percentage of oil when that oil is either paraffine of Balkhany crude oil, does not cause a similar frothing to the oleic acid, but a diminution in the size of the granules and an increase in the time required for clean up of the sands.

Other oils excepting melted tallow, the which is of no use, have not yet been examined for froth in small percentages.

Some experiments have been made using the same sized cone as in the experimental Gabbets but a much

larger vessel, i. e., 7⅜″ diameter and 7⅞″ deep, holding 4000 cc of water and 1333 gms. of ore. Other conditions being the same as in the smaller vessel experiment, the time had to be increased to clean up the sands. This evidently means that a worse proportion between the dimensions of the vessel and the cone exist when the larger vessel is substituted for the small one. Whether any proportion between the two or at the other side of the small one would give better results remains to be determined.

A. HOWARD HIGGINS.

Complainants' Exhibit Sulman & Picard Report May 3, 1905.

SULMAN & PICARD.

Copies sent C. F. Courtney
& Geo. A. Chapman
5-5-05
Received 5-5-05
Board 25-5-05

44 London Wall,
London, E. C.
3rd May, 1905.

John Ballot, Esq.,
Chairman,

Messrs. The Minerals Separation Ltd.,
62 London Wall, E. C.

Dear Sir,

We beg to hand you herewith a statement of the new method of oil concentration which we have been engaged in investigating and working out in detail, for the purpose of your forwarding to Mr. Courtney and his staff in Australia.

It will be best to start with a short statement on the principle on which the process depends.

In determining the lowest limit of Oleic acid which could be employed in granulating, it was found that granulation practically stopped at a range of about 0.5% of Oelic acid on the mineral (60 mesh Broken Hill), in an acid circuit somewhat below 1% in strength.

A certain amount of black mineral froth was, however, noticed as a result. On successively decreas-

ing the amount of Oleic acid *below* .5% it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions, and that the production of such float-froth appeared to reach a maximum when about .1% of Oleic acid on mineral was used. This froth on collection was found to consist of oiled mineral slimes mechanically holding more or less coarse (oiled) mineral particles, the froth carrying between 70 to 80% of the total mineral present in the charge. The gangue slimes and the coarse sands are left quite white in the liquor below the froth, and the balance of the coarse mineral not caught up in the black froth, but remaining mixed with the sands, is found to have been efficiently oiled and to be capable of complete recovery from the sands by table aeration.

This important discovery naturally suggested an economical method for the recovery of Broken Hill mineral quite different from any employed by you previously. The froth produced is not due to any action of the acid circuit upon traces of calcite present in the ore; i. e., *not* to the liberation of any gas in the charge by means of the dilute acid employed in the circuit.

It has been located, on the contrary, to the air introduced by the Gabbett cone during agitation, the air attaching itself to the oiled mineral slimes and to a large proportion of the coarse mineral particles, although both these materials can only be coated with an infinitesimal amount of oil, i. e., Oleic acid.

Complainants' Exhibit—Sulman & Picard Report May 3, 1905.

That the formation of froth is due to air inclusions during the agitation, and not to carbonic acid or sulphuretted hydrogen is proved by the following experiences:

(1) If it were due to gases other than air the froth should be as freely produced when .5% or more of Oleic acid is used; this is not the case, and goes to show that a minute proportion of Oleic acid is one of the factors in float froth production.

(2) Samples of 60 mesh ore have been agitated with the acid circuit liquor *without oil*, or Oleic acid, for a sufficiently long period to have decomposed any trace of calcite, etc., present in the ore. On the addition of .1% of Oleic acid thereto, and agitation by the Gabbett cone, the froth is produced just as readily as if fresh ore was employed.

(3) Sulphuretted hydrogen in quantities sufficient to produce the frothy mass is conspicuous by its absence.

(4) Additions of whiting or of calcite to the original ore failed to give any more definite froth than was obtained on the simple ore without such admixture.

The production of froth is to some extent a factor depending upon the amount of mineral slimes present in the ore the samples of ore which contain a minimum of slimes (such samples being carefully powdered to 60 mesh, by "step by step" reduction, with careful trommelling off of the fines produced at each crushing), were found to give a considerably less pro-

Complainants' Exhibit—Sulman & Picard Report
May 3, 1905.

portion of froth and to leave more coarse mineral in the sands. Nevertheless such coarse mineral left in the sands was found to be quite sufficiently oiled, and to be recoverable by aeration upon the table.

It thus appears that whether a mineral sample crushed to 60 mesh contains mineral slimes in large proportion, or the reverse, the use of .1% of Oleic on the ore is quite sufficient to afford means of complete recovery.

In our experiments carried out in the single Gabbett mixer no emulsion of Oleic acid was used, but the latter was introduced from a burette, drop by drop, to the mass of pulp whilst in vigorous agitation. In these experiments 500 grammes of ore were used in about 1,500 c.c. of liquor of acidity varying from ½ to 1% of sulphuric acid, the whole being heated to temperatures varying between 30° and 40° C.

The temperature factor is also a most important one in insuring efficient oiling ("oiling" in this case refers to Oleic acid) and in the production of froth. We now generally employ temperatures varying between 35 to 40° C. to obtain the best results. The time of agitation in the Gabbett also varies from 5 to 8 minutes, with the before stated proportions; during the agitation the formation of black mineral flocks can be traced even while the mass is undergoing rapid rotation. Directly agitation is stopped the black mineral float froth rises rapidly to the surface, and on standing for a few seconds, forms a layer of from 1 to 2

Complainants' Exhibit—Sulman & Picard Report
May 3, 1905.

inches in thickness. Below this layer is seen the turbid white or pinkish white suspension of clean gangue slimes, the coarse sands, clean in themselves but containing some coarse oiled mineral, remaining at the bottom of the mixer. By careful addition of water beneath the float the black froth (containing the bulk of the mineral present in the original charge) can be floated cleanly off over the edge of the mixer and recovered by draining or any suitable means. Should any slight amount of froth sink during this floating off process, a slight stirring by hand of the contents of the mixer will at once bring to the surface any such particles of sunk froth. The clean gangue slimes may now be poured off practically free from mineral, whilst the coarse sands can be tabled, and their mineral contents completely removed by aeration.

A very large number of experiments was carried out on this method, and the process was then tried as a continuous one. After several trials the type of apparatus illustrated in the accompanying sketch was arrived at, and is now giving excellent results (refer to diagrammatic sketch).

The plant consists of a series of Gabbett mixers fitted with the usual baffles, and speeded at from 1,000 to 1,100 revolutions per minute as regards the cone. These Gabbett mixers are identical in every respect with those used for the original Cattermole process, the first one being provided with an automatic ore feed, water circuit inlet, and an oil (Oleic acid or Oleic soap solution) feed. It communicates

with three other Gabbetts in which the agitation is continued as the pulp passes through them in series, the fourth mixer discharging by means of a swan-neck pipe into a short launder placed almost horizontally and leading into a compound spitz-lutte separator. This spitz-lutte consists of three compartments, each provided with a small water up current, and a means for collecting the material deposited in the apex of each, which may be adapted as either continuous or intermittent. It is important to note that the junction ridge of each spitzkasten with the next is about ½ to ¾ of an inch below the surface of the liquor filling the whole separator. This permits of a perfectly free travel from one end of the spitz-lutte to the other of the froth which separates from the pulp directly the contents of the last mixer are discharged upon the short launder.

It is also important that the launder leading to the spitz-lutte shall at its point of entrance into the latter be perfectly horizontal, and exactly on a level with the water line on the spitz-lutte. Any rippling action which would otherwise occur would tend to sink some of the mineral froth.

We may here conveniently note that other oils besides Oleic acid may be employed in this modified recovery process, but so far as Broken Hill is concerned Oleic acid gives by far the best results. Petroleum residuum added as emulsion, paraffine oil alone, R_3P_1 and R_1P_3 emulsions, have also been used, and all give small proportions of float, but do not act nearly so vigorously or efficiently on Broken Hill

ores as plain Oleic acid. Moreover, .1% of Oleic acid on the ore treated only amounts to some 6d. per ton, even assuming no recovery of the Oleic acid, a question which we shall consider later.

Continuing the description of the apparatus. The Gabbett contents discharged into the launder are separated by the compound spitz-lutte as follows:

(1) The mineral froth which floats over the whole length of the spitz-lutte, escapes over an accurately rounded discharge rim at its further end, into a launder, which delivers it on to any suitable filter surface; a piece of sacking or coarse, well-washed twill, is all we have found necessary for this purpose.

(2) The heavy sands and all the balance of oiled mineral particles sink in the first compartment of the spitz-lutte. Here a sufficient up-current of water is introduced to prevent fine sands or slimes settling with the coarse sands and the mineral, the object being to obtain a product which on tabling by aeration shall contain no sands sufficiently fine to float off with the concentrates but to be clearly and sharply delivered at the sand collection end of the table. By reason of the increasing width of the spitz-lutte.

(3) The fine sands are therefore deposited and collected in the second division of the spitz-lutte into which a small up-current is also introduced. This up-current tends to keep the fine sands product free from gangue slimes and also to prevent the falling of any mineral flocks from the float froth travelling over it, or to return such flocks again to the surface. Often-

times the product settling in this second compartment, which is too fine to put over the table, has been found to be so free from mineral as to be capable of immediate rejection. Should it, however, contain mineral, this can be easily recovered by means to be described later.

(4) The third compartment of the spitz-lutte also provided with a gentle water upcast, is sufficiently large to permit of the settlement of practically the whole of the gangue slimes, so that the water escaping over the lip of the spitz-lutte carries only clean mineral froth and is practically free from gangue slimes and quite clear.

We have obtained gangue slimes so free from mineral that they have been rejected without further treatment.

Clean up of second and third spitz-lutte products when these contain mineral.

Both these products being too fine to put over the aeration table, as they would naturally be floated over with the mineral on air treatment, are dealt with in one of two ways.

Their total quantity is relatively small compared with the product which settles in No. 1 compartment and with the mineral froth removed. Of course the joint amounts of Nos. 2 and 3 products will depend upon the nature of the crushing initially adopted, but they may vary from as small an amount as 3% up to perhaps 10 or 15%. For clean-up purposes they may be mixed together.

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Method A. This consists in simply again agitating in a separate Gabbett mixer, whereby any contained mineral, which is exclusively due to the sinking of a little froth mineral, is at once reliberated, and comes to the surface as float. This can be again recovered by passing over a small separate spitz-kasten. In some cases, however, although but very small amounts of material have been dealt with, two or three agitations have been required to completely recover sunk froth. As the products are, however, generally so small in quantity a complete clean up is not a matter of economical urgency as a rule, and one agitation will probably be sufficient for all practical purposes.

Method B. A quick and complete recovery in one operation is possible by blowing a current of free steam into the mixed products suspended in a due proportion of circuit liquor. The combined heating effect of the steam with the bubbling produced, completely separates every trace of float mineral which rises to the surface as froth, and when passed over another spitz-kasten can be added to the bulk of the froth collected on the filter from the main operation.

The operations are therefore summarized as follows:

(1) Gabbett agitation in the usual way with 1% Olei cacid.

(2) Floating off the bulk of the mineral as froth free from sands and gangue slimes, on to a filter surface, the liquor from which at once returns to the main circuit.

Complainants' Exhibit—Sulman & Picard Report May 3, 1905.

(3) The collection of coarse sand and the balance of the mineral in No. 1 division of the spitz-lutte; the product separated going direct to the aeration table for final clean up into coarse mineral and sharp clean sands.

(4) The fine sands and gangue slimes separated in divisions 2 and 3 of the spitz-lutte are mixed and cleaned up either by fresh agitation or by the action of a jet of free steam, the mineral obtained as float froth thereby being added to the main froth product.

The return circuit passes through a heating apparatus to keep the temperature up to from 35 to 40°C.

Mode of addition of Oleic acid. In the experiments first carried out in a single Gabbett mixer it was found that the Oleic acid could be added direct in the proper proportion without any previous emulsification, etc., but in the continuous plant this was found to be impossible, as three small drops of Oleic acid were all that was required for 60 grammes of ore according to the size of the burette drop which happened to be employed by us in our plant. Under these conditions we found that some mineral was swept from the first into the second Gabbett without efficient oiling and that other portions of mineral were doubtless unduly oiled, owing to the insufficiently rapid break up and dissemination of the oil drop.

Oleic acid emulsions in water are, as you are aware, unsuitable as they are difficult to prepare, are very unstable and require efficient agitation apparatus to keep them sufficiently mixed, and they tend to become

thicker and un-uniform in flow after a short time. We have, therefore, returned to the use of Oleic soap solution with the best possible results. We employ merely a 1% solution of Oleic acid as soap, i. e., just neutralized with caustic soda. The degree of alkalinity of this soap is so small that it is at once decomposed by the acid circuit, without perceptible diminution of the acidity of the latter; the result is that the Oleic acid is thus liberated throughout the mass of the pulp to be oiled in a state of the finest chemical division, and the most efficient and uniform oiling of the mineral particles is thereby insured. Further, instead of adding the Oleic acid at the rate of 2, 3 or 4 drops per minute to the Gabbett contents, 100 times this amount of Oleic soap solution is used, and permits of easy and exact regulation. We have thus obtained of late cleaner sands, and especially gangue slimes, than in any experiments where drops of straight Oleic acid were used.

This method also affords a further economy in Oleic acid, as both the float concentrates from the table and the float froth require to be "broken down," i. e., to have their Oleic acid removed by soda, as Oleic soap, before they can be vanned into clean blende and galena products. The soap solution resulting from this breakdown is all that is required for the initial oiling of fresh mineral by the above described process. The Oleic acid is therefore of necessity recovered in the process and in the state in which it is required for re-use. This is not undertaken merely for the purpose of

recovering Oleic acid, but as a necessary step in rendering the concentrates fit for vanning separation into blende and galena.

One important point remains to be noted in the breaking down operation.

The caustic soda solution used should not exceed 1% in strength and should be made up with soft, or rain water, i. e., which shall be free from lime or other salts. Unless this precaution be observed the Oleic acid cannot be cleanly removed from the concentrates, as small amounts of insoluble calcium or other soaps remain mixed with the concentrates or attached as microscopic films on the mineral surfaces, and lead to considerable float losses when such imperfectly cleaned mineral is sought to be separated on the vanner or other table.

If the mineral products after breaking down be accurately sized to varying mesh, limits in a MacDermott or other sizer, we have obtained indications that separation into blende and galena may be obtained in upcast apparatus adapted to the varying products, instead of employing vanner tables; but we have not yet fully worked out this idea.

The size of the compound spitz-lutte employed by us in the above trials was 2 ft. 6 ins. in total length, 2 ins. in width at the narrow end, and about 20 ins. wide at the broad or discharge end. The three divisions were necessarily rhombic in plan, but each one being such that the average slope of the sides was between 50 and 60° in order to insure no sand or other product resting upon them.

P. 1124, L. 30, Insert before " plan ", " top plan, but each was brought to a cone shaped bottom the depth of "

Complainants' Exhibit—Sulman & Picard Report
May 3, 1905.

A further modification of the whole process may be as follows:

(1) The subjecting of the suitably crushed ore to a water grading separation into two products, the first product being sharp ore, the second containing all fine and slime ore. The subjecting the coarse ore to plain air flotation clean up in an acid circuit on an aeration table without the addition of any oil or Oleic acid.

(2) The before described oil and frothing method to be applied to the fine grade material in the manner before detailed. In any event, and whichever method be adopted, the consumption of Oleic acid is now reducible to an absolute minimum and need not exceed at the outside a very few pence per ton.

It will be obvious from what has been said as to the necessary recovery of Oleic soap that the limitation of Oleic acid to .1% is by no means essential, and if better frothing and oiling of mineral is insured under Australian conditions by employing .2 or even .3% of Oleic acid in place of the .1% herein described, these amounts can be safely employed as they are recoverable to at least from 80 to 90%.

Standard large scale runs are in progress on both methods, but we regret that we shall not have weights and assays of products in time for despatch to Australia by this mail.

The efficiency of the process hardly requires these assay figures, as the cleanliness of the products from mineral is sufficiently evident.

We are, dear sir,

Yours truly, SULMAN & PICARD.

Complainants' Exhibit Cable Hoover to Hyde, January 18, 1910.

WESTERN UNION TELEGRAPH COMPANY.

III WY N 45-28 Collect I extra 6:14 P. M.
London via Palo Alto, Calif Jan. 18.-10.

Prof. James M. Hyde
2343 C St., San Diego, Calif.

Canjearon	W. U. Code
Capestoulde	Can you come
London	London
Disoxidate	all expenses allowed
Igonmene	in order to see
Grabhuegel	process
Koetjes	working
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Disossato	expenses
Koolapel	for a year
In Modico or	in Mexico or
Demussamus	elsewhere
Digester	examination
properties	properties
Hoover care Mineration.	Hoover care Mineration.

Complainants' Exhibit Cable Hyde to Hoover, January 20, 1910.

THE ANGLO-AMERICAN TELEGRAPH COMPANY.

San Diego, California.

To Mineration
London

Hoover	
Canjearson	Western Union Code
caperolan	Can come
fludiabunt	one month (?)
consension	very desirable
bevisichte	on private affairs (?)
fumidi	provided the opportunity is not lost
burenque	Can you
dissaeptos	telegraph funds to meet immediate expenses.

James M. Hyde.

Complainants' Exhibit Cable Hoover to Hyde, January 21, 1910.

Jan. 21, 1910.

To James M. Hyde.

£100 will be telegraphed if you can leave during next week.

Complainants' Exhibit Cable Hyde to Hoover, January 24, 1910.

THE ANGLO-AMERICAN TELEGRAPH
COMPANY.

Palo Alto, California.

"via ANGLO."

Jan. 24, 1910.

To Mineration,
Ldn.

Hoover	will leave
exertment	during this week
Klemhaken	telegraph funds to meet immediate expenses
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Sandiego	San Diego.
	James M. Hyde.

Complainants' Exhibit Sulman & Picard Report February 24, 1910.

24th February, 1910.

John Ballot, Esq.,
Chairman of the
Minerals Separation, Ltd.,
62 London Wall, E. C.

Dear Sir:

We beg to report on research work we have done in connection with mineral flotation during the past two or three months.

Complainants' Exhibit—Sulman & Picard Report February 24, 1910.

Such work arose from a consideration of the patents of E. J. Horwood (Commonwealth Patent June 13th, 1909) and the later one of F. Burnett Dick (No. 16667, Aug. 7th, 1908), both of which have been published. The subject matter of both patents is well known to you, and may be summarized as follows:

Horwood takes lead-zinc sulphide concentrates, etc., and submits them to an oxidising calcination at a temperature sufficient only to attack the lead particles, and to cover them with the layer of oxidised material incapable of flotation by oil.

Subsequent oil treatment therefore only removes the blende, and the separation is thereby effected. Horwood also claims to do the same by wet methods, and we think we have already reported to you that we consider our own work in this line to have been anticipated by Horwood.

F. B. Dick limits his method to the extraction of copper from oxidised ores. The ore is crushed fine and heated to redness in a reducing atmosphere, the ore being thereafter cooled in the same. The copper is found to be reduced to a form capable of flotation by small quantities of oil, when the pulp is submitted to the action of a gas. As you are aware, Dick, of Messrs. Johnson & Sons, has worked his patent in connection with the Elmore process.

We understand that a certain company is introducing the combined process of Dick and Elmore in Rhodesia, but that the Tanganyika people are considering a form of "metallising" copper into prills, and re-

covering the same by ordinary means of concentration.

The question of the validity of Dick's patent, as you are doubtless aware, has been open to considerable discussion. Others before Dick have reduced copper ores in the same way, and have recovered them by concentration; and at the date of Dick's patent oil flotation was a recognized method of concentration.

The obvious contention was therefore that from the state of the knowledge of the art, and the known facilities existing at the time, Dick's patent disclosed nothing new. We ourselves do not think however that this contention can be upheld, and we are inclined to think that Dick has a valid patent for the specific combination claimed by him.

Returning to Horwood's patent, you will be aware that Mr. Donald Clark's article in the Mining Magazine for January, 1910, describes this in detail (page 56, etc.), and that on page 8 of the same magazine an editorial states that a patent covering exactly the same ground has been granted in the United States to H. A. Wentworth. This patent is No. 938732 of November 2nd, and is assigned to the Huff Electro-Static Separator Company, of Boston.

In carrying out investigations on the above lines we found the need of a frothing apparatus which would separate the froth sharply from the settled gangue without the use of spitzkasten plant, which is never satisfactory on the small scale for a sharp clean-up. We constructed several forms of apparatus, but finally adopted the sliding top-principle with an electrically underdriven agitator; this has proved a most excellent plant, and has been in-

spected by your Mr. Hoover. Mr. Sydney Stevens has recently worked it and expresses complete satisfaction with it. It would be well to have this construction in a larger size, and this we believe Mr. Hoover intends doing.

We may mention that simple as are the details apparently it took us a month or more to effectively work out. Inasmuch as heavy oil particles may still persist in the sunken gangue, it was necessary to devise some form or surface-tension apparatus for recovering these. As our space is limited, and spitzkasten plant is awkward to work on the small scale, we have constructed a new tube apparatus with mechanical ore feed, etc., through which the gangue residues can be passed. This gives in effect all recoveries that could be yielded by spitzkasten plant in a much smaller space, and in compacter form. It is in these two types of apparatus that we have carried out our experiments.

We have since November 10th, 1909, taken out five patents. We beg to hand you the official receipts for the same. They are as follows:

No. 26019 Sulman & Picard dated November 10th, 1909. This is for the wet sulphiding treatment of admixed oxidised ore particles. If the particles are not oxidised to start with they are submitted to an oxidising calcination, and thereafter to sulphide treatment by keeping the solution faintly acid with sulphuric acid, and adding sulphuretted hydrogen, or a small quantity of soluble sulphide insufficient in quantity to neutralize the acid; the lead particles and the copper particles, etc., are sulphided in preference to the oxidized iron and zinc particles.

Such sulphiding is only superficial, but sufficient to take an oil film. This therefore promises to give a separation of lead, copper, etc., from zinc and iron, whilst the metals are oxidized. In one experiment (the best one) we obtained a recovery of a little over 80% of the lead from an oxidized Broken Hill ore, which was sufficient to demonstrate the possibilities of the application of this method. The details of the process are fully set out in the specification which we have instructed Messrs. Boult, Wade & Tennant to send you, together with the further following four provisional protections referred to.

Specification No. 28612 Sulman & Picard, December 7th, 1909. This again is for the sulphiding of certain oxidized ore products, and has more especial reference to copper and lead.

In this case the sulphiding of the oxidized metal is performed dry and at a sufficiently high temperature on a furnace hearth; sulphur or pyrites being mixed with the charge, the copper, etc., takes up the sulphur vapors and becomes covered with a layer of more or less dense crystalline sulphide. This process may be regarded as analogous to Dick's process, except that instead of reducing the oxidized ore to the metallic condition it is converted to, or covered with, a layer of sulphide, and thereby rendered amenable to oil separation.

The details are fully set forth in the specification small scale tests made in bottles before the completion of the the apparatus before referred to gave indications of good recoveries, but the time at our disposal has not been suffi-

cient to make properly quantified tests upon various ores. Both these processes, and the preceding one, we suggest should now be investigated more thoroughly.

Whilst experimenting with ores containing low metallic contents, the difficulty of forming a coherent froth from a small amount of material was, as previously hitherto experienced. We found that the addition of a little lamp-black or other suitable form of finely divided carbon gave strong froths which were capable of supporting small quantities of heavy oiled-metallic particles.

Further, we have found that finely divided freshly precipitated metallic sulphides, especially those of lead and copper possessed the property of forming oil froths of considerable stability and volume. For example, if in treating copper ore, small amounts of copper go into solution, the addition of sulphuretted hydrogen to the pulps will precipitate the copper as finely divided sulphide, which then forms a heavy froth with oil, and is capable of giving a better float recovery then would be obtained without it.

The flocculent metallic sulphides thus produced acted better than lamp-black.

Both inventions were protected as follows:

"Lamp-black" No. 29364 December 15th, 1909. "Precipitated Sulphides" No. 29616 December 17th, 1909.

We should suggest work only on the latter at present. Here again, as most of the experiments were on the bottle scale, further work is necessary in mechanical apparatus.

Complainants' Exhibit—Sulman & Picard Report
February 24, 1910.

The last of the specifications is No. 30182 December 24th, 1909. "For the recovery of oxidized mineral substances by oil." In this invention we took advantage of the acid properties of oleic acid or other fatty acid to decompose carbonate ores, or to unite with metallic bases, i. e., oxides; the latter becoming covered with a layer of greasy insoluble "metallic soap" which is capable of adhering to air bubbles. The use of "metallic soaps" in regard to sulphide particles has already been suggested by us, but the difficulty was to get these sticky and highly dense and insoluble soaps to diffuse themselves uniformly in a pulp, and to get them to stick to sulphide particles. Moreover experience has shown of late years that sulphide particles can be more effectually floated by other means.

This invention however, is a new application entirely of the principle in regard to *oxidised ore;* and it is also new in regard to forming the "metallic soap" upon the particles themselves.

More oleic acid is required to effectively float carbonates than would be required for sulphide ores of the same value, because the carbonates chemically absorb much of the oil, and combine with it, whereas with sulphide ores, the minute film was only a physical attachment to the particle.

Nevertheless the treatment of the recovered concentrates by alkali results in the recovery of practically all the oleic acid as soap solution, and the addition of sulphuric acid to this in the small equivalent proportions re-

quired, liberates the oleic acid for re-use on a fresh quantity of ore.

The amount of oleic acid employed by us on copper carbonate ores have varied from ½ to 1½%. In the latter case however, we recovered over 95% of the oleic acid for re-use by treating the concentrates in the way described.

Although fair amounts of froth were obtained these were illusory as regards the savings, i. e., a fair amount of green froth from a malachite ore was not attended with the same recovery as would have been the case with a sulphide ore yielding the same volume of froth. It was therefore necessary to treat the sunk material in the tube, i. e., to employ surface tension methods rather than frothing. Combining the two methods, from a Rhodesian copper carbonate ore containing 8% of copper the best recovery obtained was 82%. The method is fully described in the specification, and may well form the subject of further research.

During the past month our time has been occupied to a considerable extent with other investigations, and we have already informed you of work we have been doing with regard to the concentration of a Finnish ore; complex lead, copper, zinc, sulphides. Though the experiments are not complete, the results so far obtained are encouraging.

We are dear Sir,

SULMAN & PICARD.

Complainants' Exhibit Letter Minerals Separation to Hyde March 2, 1910.

Dictated to M. E. P.
By J. B.
Enclosures

MINERALS SEPARATION,
Limited.
62 London Wall,
London, E. C., 2nd March, 1910.

James M. Hyde, Esq.,
62 London Wall, E. C.

Dear Sir,

As explained to you, a private syndicate has been formed in connection with my Company, for the special purpose of exploring the Republic of Mexico, with a view to finding mines, ores, dumps or tailings, preferably amenable to profitable treatment by the Minerals Separation processes—and to endeavor to acquire such mines, ores, dumps or tailings wholly or in part, if such can be done on sufficiently advantageous terms, or to secure the adoption of Minerals Separation processes by mine owners under royalty, in cases where a direct interest cannot be acquired—and if successful to form a larger Company to handle the interests so acquired.

To give effect to this, and after fully discussing the policy with your goodself, it has been agreed to retain you to give your services exclusively to make the necessary investigations in Mexico, and carry out the object

Complainants' Exhibit—Letter Minerals Separation to Hyde March 2, 1910.

and intention of the Syndicate to the best of your ability, on the following terms and conditions.

That you will, as soon as directed, proceed to the City of Mexico, and, after conferring with the Syndicate's agents and friends there, devote the whole of your time and your best endeavours to carry out the work and without delay visit all the most likely districts and individual mines in the Republic, or such mines and districts as you may from time to time be directed to do, and carefully inspect their ores, dumps, etc., to ascertain quantity in sight, the value by careful sampling and treatability by Minerals Separation process as far as that may be possible, with the field apparatus you will be provided with. You will also ascertain, as far as possible all local conditions governing labour, supplies, transport, market for products, water, fuel, power, etc., which may have a bearing on the possibilities of successful mining or treatment operations.

You will fully, faithfully and concisely report in writing all results and information, so soon as obtained, together with your views and recommendations, direct to the Syndicate, or to the Chairman of Minerals Separation Ltd., 62 London Wall, London, E. C.,; in all other respects all such information obtained shall be retained by you in strictest confidence and shall not be communicated or disclosed to anyone, except on written authority from the Syndicate, Messrs. Lazard Bros., or the Chairman of Minerals Separation Ltd.

If any property, or properties, are found which you

Complainants' Exhibit—Letter Minerals Separation to Hyde March 2, 1910.

consider likely to suit the purpose of the Syndicate and for that reason to be worth further investigation, it may be desirable, in addition to such investigation, to arrange to send to England a bulk sample of the average ore for test and treatment, which you will accordingly arrange for and consign to Minerals Separation, London, through Messrs. Lazard Bros., of Mexico City, or as they may direct.

For the purpose of this undertaking, and to enable you to test ores on the spot, Minerals Separation will disclose to you its various processes, and give you all information in connection therewith, you undertaking to keep all such information confidential, and not to make use of any of it for any purpose except that of the Syndicate, and further you undertake and agree to communicate to that Company (Minerals Separation) any ideas for the improvement, modification, or addition to the processes, mechanical or otherwise, which may occur to you, or which you may make, and such shall be the sole property of the Minerals Separation, and you will immediately, or whenever called upon, sign all documents necessary to protect the same by patent, if so desired, and to convey the title to that Company by assignment or otherwise.

The agreement shall be for a period of one year from 1st Feby 1910, the Company reserving the option to continue your services for another year on terms to be mutually agreed upon.

The consideration for the services to be rendered by

Complainants' Exhibit—Letter Minerals Separation to Hyde March 2, 1910.

you shall be at the rate of £1000 per annum, payable monthly, or quarterly, as you may desire. The Syndicate shall also pay all your reasonable travelling and other expenses connected with the business—of which proper account shall be kept, and rendered monthly or quarterly, it being understood that such travelling and other expenses shall be kept within the limits, justified by the spirit and intention of the expedition.

In the event of any desirable business offering you shall actively assist any of the Company's or Syndicate's agents, or representatives, in carrying on any negotiations for dealing with or acquiring the same—no definite or binding negotiations for properties to be undertaken by you without the Syndicate's authority—nor are you in any way to commit the Company or Syndicate to any undertaking or responsibility without their previously obtained written authority.

If you accept the engagement on the foregoing terms and conditions, I am authorized to confirm the agreement for and on behalf of the Syndicate, in the name and for and on behalf of Minerals Separation Ltd.

I am, dear Sir,

Yours faithfully,

JOHN BALLOT

For and on behalf of

MINERALS SEPARATION LIMITED.

Complainants' Exhibit, Hyde Acceptance, March 3, 1910.

MINERALS SEPARATION,
Limited.

62 London Wall,
London, E. C., 3rd March, 1910.

John Ballot, Esq.,
Chairman of the Board of Directors,
Minerals Separation Ltd.,
62 London Wall, London, E. C.

Dear Sirs:

I have received your letter of March 2nd, 1910, for which I thank you, and I hereby accept employment with the Minerals Separation Ltd. on the terms mentioned therein and in the cables between T. J. Hoover and J. M. Hyde dated January 18th, 20th, 21st and 24th, 1910.

I am, dear Sir,

Yours truly,

JAMES M. HYDE.

Complainants' Exhibit, Nutter Report, July 28, 1910.

MINERALS SEPARATION LIMITED
62, London Wall, London, E. C.
28th July, 1910.

Dictated to M. E. P.
By E. H. N.
Enclosures 1

To the Board of Directors
Minerals Separation Ltd.,
62, London Wall, E. C.

Dear Sirs,

I hand you herewith a report on the costs of construction and operation of the Minerals Separation Plant at Broken Hill, N. S. W.

This is not a complete report, as certain phases of the same subject will be referred to in a later report.

I am dear Sirs,

Very truly yours,

(sgd) Edward H. Nutter

* * * * * * * *

A REPORT ON THE COSTS OF CONSTRUCTION AND OPERATION OF THE MINERALS SEPARATION PLANT AT BROKEN HILLS, N. S. W.

* * * * * * * *

Complainants' Exhibit—Nutter Report July 28, 1910.

Recoveries. We have seen how the bad design has affected construction and operation costs. We come now to the effect it has on recoveries. As stated elsewhere it is important to provide means for determining the actual rate of feed to a flotation plant at any instant. While I was in Broken Hill some daily records were kept in such a way as to show the relative efficiency of the different shift bosses. A record was kept of the tonnages treated, supplies used and concentrates produced on the different shifts. The day shift on May 27th produced 109 tons of concentrates from 293 tons tailings, using 168 lbs. of eucalyptus oil and 78 cwt. of acid. The afternoon shift got 99 tons from 294 tons of crudes, with 168 lbs. of oil and 99 cwt. of acid. The night shift got 81 tons from 255 tons of crudes with 182 lbs. eucalyptus and 91 cwt. acid. The day shift on June 2nd got 102 tons from 286 tons crudes, using 126 lbs. eucalyptus and 91 cwt. of acid. On the afternoon shift 110 tons of concentrates were produced from 277 tons crudes with 126 lbs. of oil and 59 cwt. of acid. On the night shift the results were 106 tons of concentrates from 280 tons of crudes with 126 pounds of oil and 75 cwt. of acid.

The comparative sheets show that the material treated during the weeks in which these dates occur was practically the same in sizings and assays.

Complainants' Exhibit—Nutter Report July 28, 1910.

Time.	Pounds concentrates per ton of crudes.	Concs. ratio.	Pounds acid per ton concs.	Pounds acid per ton crude.	Pounds oil per ton concs.	Pounds oil per ton crude.
Iay 27th						
shift	833	2.678/1	90.19	29.82	1.541	0.574
ernoon shift	754	2.97/1	112.00	37.72	1.697	0.572
ht' shift	712	3.15/1	132.7	42.15	2.248	.713
une 2nd						
shift	799	2.80/1	99.9	35.64	1.235	0.441
ernoon shift	890	2.55/1	60.1	23.85	1.145	0.455
ht shift	848	2.64/1	79.3	30.00	1.188	0.450

These figures indicate a wide variation in results during the different parts of the same day. The figures are really incomplete without complete assays showing metallic and insoluble percentages for the same periods. The insoluble is not apt to vary greatly, however, so we can take the figures we have, as approximately indicative of the work done. The difference per ton on recoveries between the best and the poorest with the concentrate assumed to assay Ag 15 ozs. Pb. 9.4% and Zn 47% in each case would amount to 4/10 per ton of crudes with zinc at £21. The difference between the same ones on costs of oil and acid used would amount to 7d for acid, and 2d for oil, making a total difference of 5/7 between the best and the poorest.

If we take, in the same way, the difference between the best results and the average we will get an indication of part of the constant loss due to poor regulation. This works out on recoveries to 2/3.6 per ton of crudes, and

4.3d on oil and acid consumption, or say 2/8 per ton of crudes.

It is a practical certainty that the best results shown in this comparison are below the best possible results obtainable by complete knowledge and exact regulation, for these are merely the results of more accurate guessing at the proper feed and regulation by one shift boss, compared with the others. We could only hope for him to get the best results occasionally, and by accident. It is a very safe assumption, then, to assume that exact knowledge of the rate of feed of all quantities, and the consequent exact control, make a difference, and has made a difference of at least 3/- per ton. We have then a further charge of about £90,000 in possible profits that can be charged to bad design.

The various items summarize as follows:

Unnecessary charges in the construction costs

	Material	£4139	
	Labor	4890	
		£9029	
	say	9000	
			per ton on 600,000
Unnecessary working costs as a result of bad design or otherwise		1/0.34	£30850
Loss in recoveries, due to bad design, say		2/3.9	£70,000

Complainants' Exhibit, Nutter Report, December 3, 1910.

MINERALS SEPARATION LIMITED.

62 London Wall,
London E. C.
3rd December 1910.

Dictated to E. N. P.
by E. H. N.
Enclosure 1.

The Board of Directors,
Minerals Separation Limited,
62 London Wall, E. C.

Dear Sirs,

I transmit herewith a paper entitled "Technical Developments of Minerals Separation Process," which is the last of the Reports based on my trip to Broken Hill.

Very truly yours,
Edward H. Nutter.

TECHNICAL DEVELOPMENT OF MINERALS SEPARATION PROCESS.

It would be hardly accurate to refer to this paper as a report as it is almost necessarily an argumentative discussion embodying my personal views concerning the relative importance of the various unsolved problems, and the most promising lines of investigation leading to their solution.

Complainants' Exhibit—Nutter Report
December 3, 1910.

One of the most important group of problems is that concerned with the development of the best design of plant for carrying on the essential operations which go to make up the Minerals Separation flotation process. It is to be understood of course, that no design can be completely worked out in advance that will be suitable for all ores, or for any ore. The different parts of the general problem will have different weights in the different cases, and the relative importance of the different operations will hardly be the same at any two mines. In other words each ore presents a separate problem to us as well as others. It is safe to say that there have been more metallurgical failures as a result of lack of appreciation of this general truth, than could be traced to any other cause. It is important however to crystallize our knowledge into rules for estimating the weights of the different variations to be met with as much as possible, so that we need take the minimum of time in working out a design to meet particular conditions. Thus, given a complete analysis of an ore and assays of the different sizes of a finely crushed sample of it, we should be able to tell approximately what we could do with it as soon as we get a few small scale results. Before the last word can be said as to what is the best standard design of a plant, a lot of experimental work will have to be done, and new apparatus designed or invented.

It is of course our object to find conditions under which all the possible ores can be worked. It is also our object to raise extractions to the highest practicable fig-

Complainants' Exhibit—Nutter Report
December 3, 1910.

ure. We want to develop the process so that it will be a process of general application, in the treatment of base ores.

In many parts of the World there are ores of varying degrees of complexity in which the minerals are so intermixed as to interfere in the commercial extractions of each other, and the value of the ore is thus reduced far below what it might be if good separations could be made. To this type belong various lead zinc silver, lead zinc silver copper, and zinc copper ores. These comprise a large class among which are some highly important ore bodies. Portions of the Broken Hill ores, some of the Tasmanian ores, and some of the basic ores in North America are examples. The separation between the various sulphides present in such ores is a highly important problem then, if not the most important problem ahead of us.

A problem of about equal importance is the development of apparatus and process for the treatment of disseminated copper ores so that on at least the combined basis of recovery and cost we can compete directly with ordinary wet concentration machines and methods. If we can make a showing of increased net profit in the treatment of Ely, Nevada ores, and various of the Arizona and Montana ores, as compared with the wet tabling now in use and planned, we would tap an immediate source of large income. The exploitation of this business involves pressing the investigation of distillation products from wood, as wood tar oils will probably

prove to be our most general frothing agents for copper ores.

Another highly important problem, but one necessarily forced into the back ground by the others, is the finding of a flotation treatment for oxide and carbonate ores. Connected with and forming really a part of the preceding problems is the development of treatment and apparatus for getting good commercial results in cold circuits, that is circuits at atmospheric temperatures.

Important parts of the preceding general problems are the design and choice of apparatus for feeding the various ingredients to a plant in the EXACT proportions required, and the performance of each necessary operation with maximum economy.

All of these require that any scheme of treatment devised shall give maximum recovery without the sacrifice of grade of product, and with the consumption of minimum amounts of reagents, and of fuel and power. In other words the controlling factors and conditions are always commercial ones and we must not lose sight of the fact that our endeavours must be guided by commercial requirements. These requirements dictate that we must determine the limits of our various reagents, particularly the cheaper, most abundant and most widely distributed ones. When any particular ore comes in then, we should devote ourselves to finding out what results are obtainable with the reagents which commercial considerations will confine operations to. A corollary of this is to find the upper limits with each frothing agent

which does not interfere with subsequent tabling and vanner work. This is particularly important in the case of petroleum.

Differential Separations. By differential separations, I mean separations by flotation, either directly or indirectly, between two or more valuable minerals. The separation by differential flotation or flotation sizing, between blende and galena, in such ores as the Broken Hill ores in which both the blende and galena are flotable is an example. Along this line some promising partial results have been obtained.

For instance while I was in Broken Hill a number of samples were taken of the froth floating on top of the pulp in the various mixers in both plants. All of the series of samples taken showed a tendency on the part of the silver to float ahead of the lead and of the lead to float ahead of the zinc.

A series of samples taken from the mixers of the zinc section of the Sulphide Corporation Company's mill during the first week in May 1910 assayed as follows:

		Ag.	Pb.	Zn.
General assay for week.		6.5	6.4	19.9
Mixer	No. 1	30.4	33.4	29.0
"	No. 2	26.0	29.2	30.6
"	No. 3	17.2	16.0	42.2
"	No. 4	11.6	10.8	44.2
"	No. 5	14.6	12.9	42.2
"	No. 6	13.4	11.1	44.0

Complainants' Exhibit—Nutter Report
December 3, 1910.

This was the best set of results obtained. In others the lead was lower in the first two mixers.

This tendency for different minerals to float differently has been noticed from time to time in experimental work on different ores, but so far the results have all been indeterminate.

It would appear that the hope of accomplishing a differential separation in one operation, or of finding a flotation reagent that would effect a direct and complete differentiation between different sulphides, has led experimental work away from the lines which appear to hold out most promise.

A differentiation such as that tabulated above lends itself to only a limited number of explanations. Either one mineral tends to float easier than another mineral, on account of intrinsic differences between the two, or else the apparent preferential effects noticed have been the result of differences in size and shape.

If the first is the correct explanation of the observed differentiation and I think it is, it would be reasonable to assume that the action is as follows: With an air or gas saturated solution the points at which free gas first begins to form, are those points where the forces tending to hold the gas in the ionized state, are first overbalanced by the forces tending to pull the gas into the free state. Pointed solid particles have a decided influence on such phenomena, and this fact is made use of in every chemical laboratory to give quiet ebullition instead of bumping when solutions are being boiled.

Complainants' Exhibit—Nutter Report
December 3, 1910.

If there is a pointed object in the solution near the point of heat application, the steam bubbles form readily at the point and pass off quietly. If there is no such pointed object, and the interior of the glass vessel is very smooth and the solution is clean and free from particles, the steam forms intermittently and explosively, and the bumping is at times so violent as to break the containing vessel.

Now it would not seem un likely that different sorts of points would have different powers in this regard, and if a "smooth round" point and a sharp ragged or rough point both of the same material were placed close together, ebullition would begin at one in preference to the other. It would also seem not unlikely that if two points, one say of galena and the other of glass, were placed close together, that ebullition would begin at one in preference to the other. In the same way, as between two galena points, one of which had been oiled or acid treated or both and the other had not, a preference might be shown. Likewise, as between two points of any differing material, such as galena and blende, or galena, blende and chalcopyrite, one of them would probably be preferred to the others. This suggests what might prove to be an important line of experiments. That is, a careful determination of the different temperatures at which ebullition begins by using points of different minerals ~~materials~~. Should we find, for instance that when points of galena and blende were used, that ebullition always began first at the galena and at a lower temperature than at the

blende, it would indicate that galena exerts a stronger pull on gases about to come out of solution than does blende. A determination of these temperatures for various conditions with different minerals will enable us to more intelligently control the operations of experimental plant runs. A start has been made on this line of experiments. One reasonable explanation then of the differential flotations we have observed would be that a preferential gassification does ~~not~~ take place on the galena particles, as compared with the blende particles, and the tendency is therefore to float the galena particles first. The tendency is not sufficiently pronounced, however, to give sharp separations, at a single operation.

If this is the correct explanation, we can hope for differential flotation becoming a fact as the conditions surely ought to be found that will enable us to repeat the same operation on the preferentially formed concentrates, and get a richer and richer lead concentrate, say, on the one hand, and a richer and richer zinc concentrates as a residue, on the other hand by the removal of the galena, and all as a result of repeated fractionings.

Should this turn out to be the way of it, we will find probably, that variations in the acid, in the oil and in the amount of aeration will all have their effect, and some combination of these will give us the conditions for maximum differential results between any two minerals, as for instance, blende and galena.

If the hypothesis we have taken is not the correct one

but instead, the differentiation is due to differences in the mechanical aspect of the particles, it would be reasonable to expect that something like this takes place. When the solution is at the gas saturation point and the condition of overbalance is reached so that ebullition begins, there would not be any preferential selection of points by the gas coming out of solution and we would have gas forming at all the points irrespective of the nature of the material forming the points. As the gas attaching to the particles accumulates into bubbles, the smallest particles should be the first ones to float. If the action were stopped here, we would expect the finest sulphides to be floated first, irrespective of what the mineral happened to be. As a matter of fact our whole process is based on the selective tendency metallic sulphides have for floating under conditions that will not float gangue minerals. The idea that all sulphides have equal tendencies to float is logically untenable, and directly against our whole experience.

There is no sharp, clean cut separation between different sulphides, however, except when carefully sized. Hence, probably, the limits are narrow within which we can get clean results, and so far we have not succeeded in confining our test conditions to those limits.

Henry Lavers, I understand, has obtained clean separations by flotation between different sulphides after previously sizing the material but this can of course be obtained otherwise on such material. This result, however, is exceedingly valuable as furnishing sound foot-

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ing for our deductions, that there is an intrinsic difference in the tendency of different sulphides to float under the same conditions; and that repeated fractionings should yield commercial separations; and that flotation sizing is an inherent tendency and not an accidental effect under certain sets of conditions.

My own opinion of the relative commercial importance of the different tendencies enumerated is to give flotation sizing first place. It is a new classification tool and should enable us to sort out the particles in a finely crushed complex ore into certain classes depending on a different set of physical properties than any hitherto used in this connection.

If we then take these classes of particles, and subject each class separately to a different set of conditions from the first, such as obtain on a vanner or Wilfley we should have each class further split up into smaller groups as a result of intrinsic differences in other physical properties than those first made use of. I look upon this as the quickest route to a differential separation of complex sulphides. I am confident that we could design a plant from data already in our possession that would work and give commercial separations on ores of good grade not too finely crystallized that are amenable to flotation.

Thus, take the case of separations between chalcopyrite and blende, one of the most important to make, from a commercial standpoint on account of their frequent occurrence together in important ore bodies, and their

mutual interference in smelting. This separation is one of the most difficult to make in ordinary wet mills on account of these minerals having so nearly the same specific gravity. In flotation work we have found that zinc blende is very difficult to float in a non-acid circuit, while chalcopyrite floats extremely well in a non-acid circuit. The immediate inference from this is that here is the treatment we want. Remove the copper in a non-acid circuit; and then get the zinc after the copper is recovered. Work along this line however has gone to show that one of the few conditions under which we can float zinc blende in a non-acid circuit is when it is accompanied by chalcopyrite. So far as we have observed, the flotation is not clean of either mineral as we get a good deal of zinc in the non-acid froth and have some unfloated copper in the tailings. An examination of the products showed, however, that the blende particles that floated were the very fine particles only, while practically all of the chalcopyrite except the coarsest was floated. We have then in non-acid work on such ores, the copper tending to bring up the zinc, and the zinc tending to pull down the copper.

If this material were sized into say six sizes, numbered 1, 2, 3, 4, 5 and 6 of which number 1 was the largest, we would probably have in a froth produced without acid, some of the number 1 copper, most of the number 2, and practically all of the 3, 4, 5 and 6, and this would comprise the bulk of the copper in the ore. We would also probably have some of the Number 6

blende and perhaps a little of the number 5. In the unfloated portion we would have the 1, 2, 3, 4 and some of the 5 and 6 blende, together with some of the number 1 and 2 copper. If this froth should be tabled or vanned, and also the residues, we should get fairly clean copper concentrates, and fairly clean zinc concentrates. We should get also a coarse middling, and a slimy tailing, consisting probably of unsaleable mixtures of the two sulphides. The commercial efficiency of such an application of the process to any particular ore, would depend on the ratio between the saleable and unsaleable products. If the amount of middlings was too great, we would have three courses open. One, the taking off of partial products in the first instance, and tabling these separately. Should this leave too much coarse mineral in the coarse tailings as a result of robbing the pulp of the fine sulphides at an early stage, we could instead take all the sulphides off, leaving a clean tailing, and then retreat the concentrate, dividing it into partial products which could be tabled separately or not, as desired. An alternative scheme to this would be to fix the conditions of the first flotation so that a maximum of copper would come off with as little zinc as possible. A retreatment of this product by flotation could be expected to give a fairly clean copper concentrate and a zinc reject containing some copper which could go back to the first set of mixers.

These are of course, merely suggested lines of treatment, but I am fairly confident that with such an ore,

assuming that the sulphides will float, that a method of treatment involving flotation, and tabling or vanning could be worked out which would yield commercial products.

The same would in general be true of other sulphide ores such as lead, zinc or lead, zinc copper, but a simple copper zinc ore would probably be the easiest to work and offer the simplest problems. Theorizing is of course futile, unless supplemented by experimental results, but it is essential that experimental work be guided by theoretical considerations.

A little thought will show that as we deal with finer and finer particles, in which the ratio of mass to superficial area approaches infinity, that the limits of variations in differential treatment approach closer together, until with exceedingly fine particles no differential results would be obtainable.

For instance, in the case of a very fine lead zinc slime, such as that produced at Broken Hill, we would have sulphide particles which settle in water with a great deal of difficulty and slowness. It does not require much imagination to see that with such particles any condition which resulted in any tendency at all for the particles to float, even though it might be much stronger for the galena than for the blende would bring both the blende and galena to the surface together and we could effect no differential separation between them.

On material coarser than these particles, however, I think we have a right to expect that separations can be

made by a combination of partial products flotation with tabling and vanning of the separate products.

Careful regrinding by stages in short tube mills, to avoid excessive sliming, and regrinding of the separated coarser particles, so as to reduce the sulphides to minus about 15mm. screen, without the formation of much absolute slime, should quite completely separate the blende particles from the galena particles. Then, if such material were subjected to partial products flotation, very clean separations between the lead and the zinc should result. From the work done at the Zinc Corporation, I would not be surprised if zinc concentrates running under 1% of lead could be obtained in this way and correspondingly clean lead concentrates.

Such a procedure would of course involve the rejection of some unvannable slime, such as the Zinc Corporation has been rejecting, if we are to get such a clean zinc concentrate. We would remove as a lead concentrate, most of the lead that now goes to bring the lead content of the zinc concentrate up to the smelter minimum, and sell it as a lead concentrate, we could then mix in with the high zinc concentrate enough concentrate slime to bring the lead up to the required amount, and ship the mixture as a zinc concentrate. We would thus trade off the, at present, worthless lead in the unvannable slime for a good lead concentrate; and we would also get paid for the, at present, worthless zinc in the unvannable slime.

Let us take an example. Broken Hill Blende, when

P. 1158, L. 11, insert "and the partial products were then tabled or vanned" after "flotation"

pure, carries about 55% of zinc. A zinc concentrate then, containing 2% insolubles and 1% of lead would assay 1% Pb. 53.24 Zn. and say 8 ozs. Ag. per ton. If we assume that the unvannable slime sulphide assays 20 ozs. Ag., 20% Pb. and 35% Zn. and that the zinc concentrates will be fined by the smelters if running under 7% of lead, we would have in a combined concentrate mixed so as to meet this requirement the following assays—Ag. 11.8 ozs. per ton, Pb. 7%, Zn. 47.5%. This mixture would be worth £2. 18. 0. net per ton with zinc at £22.

If we started with 100 tons of concentrate assaying Pb. 7%, Zinc 47.63%, Silver 9.37 ozs. and 5% insolubles we would get on these assumptions 9.42 tons of lead concentrate worth £6.6.0. net per ton at Broken Hill and 87.69 tons of high-zinc, low-lead zinc concentrate. This last material would not be accepted by the smelters, but would have to be brought up to 7% lead again by mixing with it, high-lead, slime concentrate. The amount needed would be 40.47 tons of the assumed value. The resulting mixture would assay lead 7%, zinc 47.48% and silver 11.8 ozs. and would be worth net £2. 18. 4. per ton at Broken Hill. By this procedure then we would take 100 tons of zinc concentrate worth £2. 16. 6. per ton, abstract 9.42 tons of lead concentrate worth £6. 6. 0. per ton, and mix in 40.47 tons of present valueless slime concentrate, and get 128.16 tons of zinc concentrate mixture worth £2. 18. 4. per ton. There would be a total net increase in value of products

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of £150. 8. 7. The cost of the operations would be about £61. 9. 0. leaving a net profit of say £89. Looking at it from one point of view, we would be losing nothing on the saleable zinc concentrate, and would be working off material at a net profit of about £2. 4. 0. per ton, which is at present unsaleable. I have assumed highly efficient deleading, and I believe that highly efficient deleading would be obtained with the treatment indicated. The Zinc Corporation with ordinary water classification and tabling, deleads to below 5%. With stage grinding, partial products flotation and tabling I know that we can greatly better their results, and delead below the smelter minimum, we can utilise the unvannable slimes, and on each ton of concentrates from these slimes so utilised we would make approximately the profiit indicated. As we can partially delead any of the Broken Hill slimes, the slimes added should be mixed into the feed into the partial products plant. By doing this I would think that we should be able to utilise the slime concentrate at least in the proportions used in these calculations.

This scheme or method of treatment should enable the Broken Hill Mines to treat their current slimes at a profit and work off the accumulations from past work.

For the present, of course, such a suggested scheme has no application to the calcareous slimes at the North and South Mines, but it would be of a great deal of importance to the other mines as there is a possible two or three million pounds sterling profit in the silicious

P. 1160, L. 14, insert "results. To the extent that we do better their" before "results"

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slimes stacked and to be produced if efficient deleading of all the granular materials is attainable.

In addition to the Broken Hill ores there are the large bodies of high grade Tasmanian ores, which should be amenable to the same treatment, if it works at Broken Hill. From the standpoint of the amount and grade of material awaiting treatment along such lines there is no more important problem in ore dressing or metallurgy awaiting solution; and any promising line for investigation such as this, should not be neglected. I propose this, then, as a possible solution of the Broken Hill slime problem, and recommend it to your thoughtful attention.

NON ACID PROCESS. The development of a non acid process has reached the point where we can say with some confidence that it applies to a number of copper sulphide ores; and we have at our command a number of commercially available reagents that can be used on non-acid work, such as certain of the eucalyptus oils, turpentine, the cresol group of coal tar derivatives, wood tar oil and Stockholm tar. These yield good froths giving good extractions of copper in certain ores.

Calcitic ores in which pyrite, chalcopyrite, zinc blende and galena occur, still remain a problem until we get reagents or manipulation that gives a flotation with little or no acid, with lead as well as copper.

Experimentation along this line will naturally consist of trying all the new reagents we find, on mixed ores, without using acid.

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Another rather suggestive line of research is that of treating frothing agents with small amounts of froth deterrents with the idea of rendering the oil selective for particular sulphides only.

This whole field seems a fertile one for experimental work, and with large possibilities for new and effective frothing agents being discovered, among the products from the destructive distillation of wood, it is a most hopeful outlook.

COLD CIRCUIT WORK. An important commercial problem is the determination of the best conditions and the best form of apparatus for obtaining a good froth in a circuit at atmospheric temperatures only, on lead-zinc ores. If in connection with this, it should be found that petroleum or its derivatives could be used for Minerals Separation work many ores could be treated at a lower cost than at present. The saving would lie in the use of a cheaper oil, less acid consumption and no expense for heating circuit liquors. This might be termed an alternative scheme for use in some special cases, and for application to a wider range of ores, failing the development of a non-acid or differential process. Acid tar, a stage product of oil refining is of promise in this connection, as it gave a good appearing froth in the cold on Broken Hill tailings the first time we tried it. We know that cold circuit filming is feasible, and is producing heavy tonnages of concentrates. But it is not a slime process. We know also that the Elmore vacuum machine gives a froth in cold

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circuit. Now it is my idea that if the restricted discharge opening in the Elmore machines were not there, and that the froth were formed on a broad surface as in the Minerals Separation and Potter processes that the froth would, to a considerable extent, break down to a skin float or film. Should this be so, the reason the Elmore machine is a frothing machine is largely because it delivers the froth away from the machine before the bubbles have time to break and drop their load. It seems to me then that the development of a cold circuit process aside from the finding of some reagent that does the work at once, is going to be a matter of mechanics, that is, the development of an efficient form of bubble trapping apparatus. This as we know, is entirely feasible, and it only remains to build a set of mixers and separating compartments based on the results we got with the modified Charlotte Street mixers and the ideas developed therefrom to have an experimental set of wide and various application, for the determination of many of our unknown factors. With this machine, we can take off two products from the mineral floated from each mixer, and these products in general will differ from each other in size of particles, or flotative tendency, or both.

Part of the material we would take off would be in the form of clean concentrates and part as dirty concenrtates, which would need retreatment. In differential work all of the products would probably be retreated separately.

There are a number of sound reasons for the belief

that a combinaton of partal products flotation and retreatment of the separate products by ordinary concentrators would be the easiest and quickest way to a solution of the problem of separating the minerals in complex ores.

It enables us to make use of a large number of physical properties in separating the minerals from each other than would water classification and concentration alone or any scheme of differentiatial flotation alone. It follows unquestionably that a combination of the two methods of effecting separations between minerals, gives greater power over a complex ore than either one can alone. In other words, it enables us to make a sorting of the ore particles on the basis of one set of physical characteristics, and then take these different groups separately and resort them on the basis of another set of physical characteristics. We know that we can make partial separations by means of differential flotation. We know also that we can make partial separations of another kind by means of tables and vanners. It is reasonable to believe then, that a combination of the two methods will give us more complete separat~~ors~~ions, than either method can give us alone.

While in many cases it may be found better work above atmospheric temperatures the cold circuit should be found useful in such ores as make for high acid consumption. The criterion in all cases will of course be the balance between increased extractions on the one hand, and increased costs on the other. It seems prob-

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able that one retreatment of dirty concentrates would be sufficient to eliminate practically all the contained gangue as 15% insoluble could be reduced to about 1% aside from chats, at a single retreatment.

It would seem almost obvious that we would be able to carry the separation as far or farther with a combination of easy applications of the two methods rather than with an extreme application of either one.

It should be mentioned in passing that the carbonate and oxide ores offer a practically untrodden field for investigation and when some of the more important lines of investigation have been worked down to the smaller refinements, experimental work on such ores should be undertaken seriously, as there is certanly a great need for an effectve process to recover the values from such ores.

DESIGN OF PLANT. The material coming for treatment to a Minerals Separation plant will have originated in one of three ways. First, it will be finely ground crude ore, of which the preliminary treatment has been for the purpose of preparing it for Minerals Separation treatment. Second, it will be finely ground ore, which has already been subjected to treatment for the recovery of one or more minerals, and is sent on to the Minerals Separation process for further treatment. Third, it will be tailings which has resulted from milling operations in the past and been stacked; and has to be excavated, transported to the plant prepared for treatment, and treated.

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Of these three cases the most general is the second one, although the third involves operations that the other two do not.

Under the first case, would probably come most of the simple copper ores. The object would be to concentrate the copper mineral directly out of the ore without the use of any tables or vanners. In this class are many of the most important copper deposits. A treatment plant for such ores would consist of rock breaking, crushing and grinding machinery, in which no special care need be taken to avoid the making of slimes, as is now necessary. This would reduce the cost of preparation of material from the present figure, and be an item in favour of the Minerals Separation treatment. After simplifying the crushing we could eliminate the classification which is a large item in the capital outlay for a copper concentrator, and is usually an indirect item in the cost of operation on account of extra pumping.

This brings us to the concentration itself, and any comparison between Minerals Separation and ordinary wet methods must consider both cost of operation and recovery.

Practically the only data we have as to the cost of tabling and vanning in these large plants are the costs in the Boston Consolidated mill on Bingham Utah ores. The tabling, vanning and classifying in the Boston Mill cost 7.3 cents per ton of ore. On such ores as we find are amenable to Minerals Separation concentration, it is safe, I think, to assume that the cost of power and

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labour for Minerals Separation work would not exceed 2 cents per ton. The cost of reagents is difficult to estimate without knowing what reagents would be used or the quantities in which they would be used. From our experimental work, however, it would probably be safe to take the minimum cost for reagents on such copper ores at not less than 2 cents a ton, and the maximum at not over 15 cents a ton.

On any ore then, on which we can give a substantial increase of extraction we can compete directly with ordinary wet concentration.

I think that any plant erected for the treatment of such disseminated copper ores will have to consist of mixers and spitzkasten, for taking off the concentrates, followed by mixers and traps for sweeping up all possible remaining values from the ore. The traps would probably deliver this product to regrinding apparatus, which would in turn deliver to the head mixer again. The concentrates from the spitzkasten would probably be delivered direct to retreatment mixers where more water would be added and a clean low silica concentrate taken off. The tailings from the retreatment mixers and spitzkasten would go to regrinding apparatus, or to the head mixer again, depending on the nature of the material.

A plant providing all of these operations is quite easy of design and would be a single self-contained unit.

In the treatment by Minerals Separation of tailings coming continuously from an ordinary wet mill we

would, I think, find that for the best work, careful regulation of the feed of ore from the bins, prior to any treatment at all, would be of considerable importance. If the feed is not regulated at the very start, it will be necessary later on to spend money to straighten out the kinks in order to avoid losses as a result of irregular working conditions. It may be that the importance of this provision will be minimized by the use of trap separators and retreatment, and I am quite sure that it will be at least reduced.

There is no doubt but that various devices could be designed and arranged for automatically regulating the feed according to the weight, but I am not convinced of the usefulness of such automatic regulation unless perhaps for special cases. It is essential in all cases to have arrangements to enable the rates of feeding oil and acid to be brought easily into exact concordance with the requirements of the ore. I am inclined to believe that this requirement would be satisfied within practical limits, by arrangements which could enable the foreman or plant manager to vary his rates of feed of ore, acid, oil and water, and determine what these rates of feed are at any given instant. If a plant is handled with intelligence, such information should be ample for the foreman and superintendents to control the operations easily and exactly. If the plant is not handled with the intelligence that would make such arrangements suffice, I doubt if further refinements would help matters much, as automatic controlling devices would require a high

grade of intelligent care to keep them in proper working order.

Next in importance to a means for determining the rate of feed, at this stage of the operations, comes the sampling. This should be adequately provided for, or much of the advantage gained by controlling the feed will be lost.

The best sampling arrangement is something of a special problem in each case depending on the particular conditions prevailing at each property. At the Central Mine, where the ore is transported by aerial rope tram from the crusher bins to the mill, the first cut is taken by dumping every tenth bucket into a special sample bin. This sample is then worked down and recrushed until a convenient size for sending to the assay office is obtained. At the South Mine, the sampling mill is at the junction between the two elevating conveyors. It takes a definite cut of the ore, samples it down, crushes it and resamples it in Vezon samplers. The Central Mine arrangement is fairly good, but the South Mine arrangement is excellent.

In a mill designed for taking out certain products prior to the Minerals Separation process, such, for example, as the removal of lead by jigs and tables in the lead mill at the Central Mine, the tailings from these operations will almost certainly require dewatering before they are fit for Minerals Separation work. This is particularly necessary for lead-zinc ores, as the Minerals Separation process works best on such ores in a

closed solution circuit, and the savings in oil and heat, and the increased recovery, are great enough to pay for the extra cost involved.

At the Central Mine a very crude and costly arrangement is used for dewatering. The combined tailings from the tables, vanners and annex are run on to thickening or drainage belts. These belts are nothing but wide, deeply troughed, slow moving conveyor belts, which continuously deliver at the discharge end the sands that settle to the belt surface. The water and slimes overflow at the sides. This water of course carries with the slimes a large proportion of fine sand. The coarse sands are delivered directly to incline conveyor belts which deliver to the zinc flotation plant. The fine sand and slime is carried by launders to a series of eight settling vats through which it passes in series. From the last vat the slime overflow goes to settling ponds. One settling vat is usually out of commission at a time, being emptied. This is done by working the sands through a hole in the middle of the bottom on to a conveyor belt which transports the fine sands back and delivers them in with the coarse sands. The slime overflow from these settling vats goes to large shallow concrete basins or paddocks. The slime flows in at one corner, and the water is pumped off at the diagonal corner, until the basin has become so full that the water comes off too dirty for mill purposes. The flow is then turned into another pond and the first one allowed to stand and settle. The supernatant water is pumped off, and the

mud is spooned into small ore trucks by hand, hauled by horses to a platform alongside the return elevator, and dumped. The mud is then shovelled by a crew of men on to a conveyor, whence it joins the sands on the way to the zinc section.

This man-handling costs about 2/- per ton of slimes or 6d per ton of crudes and is a crude arrangement. The obvious thing to do at this point is to filter the combined sands and slimes. It is an open question, however, as to which type of filter is the best. The Wilfley or Oliver drum filter is more applicable to this particular problem probably than is a filter press or a vacuum filter of the Moore or Butters type. The drum filters, though, do not seem particularly well adapted to filtering a pump mixture carrying much heavy sand; and I am of the opinion that a horizontal annular ring filter, offers promise of a wider application to such dewatering problems than any other type.

Since the above was written I have been informed that the Wilfley filter has been tried recently at the Central Mine and found unsuitable.

There are, of course, certain slimes that filter with great difficulty, and these can only be handled by filtering plants of the Moore or Butters types, that have great areas of filtering surface. I would not expect the Minerals Separation process to have much application to ores of this extremely slimey character however.

Any estimates of the cost of filtering are of course unreliable unless they are based on tests on the ore to be

filtered, but from what I have seen of the Central Mine ore, it seems to me that 2d. per ton should be a sufficient allowance for dewatering the pulp between the lead mill and zinc mill. As the crude, sloppy and unscientific method they pursue now costs 6d. per ton of ore, a filtering plant would pay for itself quickly and be in every way better. The Central Mine management appears to be alive to this fact.

The Central Mine operations illustrate the point, however, that some sort of dewatering arrangements will have to be provided for, ahead of the Minerals Separation plant, where it is installed as an adjunct to an ordinary wet concentration mill. The necessity for filtering or dewatering will be much lessened if we find we can do successful cold circuit work.

In the continuous treatment of an ore such as Central Mine ore, while it is important to regulate the tonnage going to the Lead Mill, and know the rate of feed, it is more important to know the rate of feed to the Zinc section, so that the oil and acid can be regulated exactly. A continuous conveyor weigher would probably be the best working device, if room enough in the conveyor belts was available. Failing this, a pan to swing under the feed and catch it for a definite interval, would be simpler, and the next best arrangement.

I have already shown in a previous report, how greatly the recoveries are affected by variations in the rate of addition of oil and acid. As a matter of fact, the introduction of means for regulating the feed and for de-

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termining its rate, are chiefly for the purpose of providing data from which the oil and acid feed can be determined. We will assume then that we know the rate of feed of material to the mixers, and from experimental work, the proper quantities per ton of oil and acid to give the best results. These reagents are to be fed steadily at the determined rates. If it should be desired to change the rate, this should be done easily and certainly.

There are three different general ways to control the feed of oil and acid. One is to feed a definite weighed quantity, at prescribed intervals. Another is to feed a definite measured volume at prescribed intervals, and a third is to have a definite even flow of material, which will, of course, deliver a definite weight and volume in a prescribed time interval.

The first method, that of weighing out quantities of oil and acid and adding them at stated intervals, seems impracticable, and I am unable to conceive a form of apparatus, worth a second thought, for doing this. The third method, that of adding the oil and acid in an evenly flowing stream of definite rate, would seem at first glance an easy and practicable means of adding these reagents at the proper and desired rate. There are practical difficulties in the way of doing this, however, and I have been driven to the conclusion that other means would prove better.

With any liquid the flow through a given orifice varies as the square root of the height of liquid above the orifice. The general expression for the law is $V = c \sqrt{2gh}$.

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If c could be taken as constant for any given material through any given orifice, and the value of it determined experimentally, our problem would be easy. Unfortunately c is a quantity which varies with the viscosity of the material flowing through the orifice; and with most of the oils of importance to us, the viscosity varies widely with the temperature. In order then to use a feeding device based on this principle, the temperature would have to be maintained constant. This, of course, can be done, but it involves additional care and expense. Another practical difficulty, too, would be, in the case of oleic acid, the uneven texture of the material. Unless it is kept quite hot, films and lumps form which plug up a small orifice. This caused a good deal of inconvenience in the trials at the Zinc Corporation, and vitiated some of the results.

In ordinary crude commercial sulphuric acid there are usually flakes of sulphate, and other foreign particles which have to be guarded against, as they could easily give trouble in a small orifice.

It would seem, then, that some positive feeding device would be better if a simple and effective one could be built.

A various assortment of devices could be made to fulfill this purpose, but the one that seems to me to offer the most promise for satisfactory working and maintenance is some modification of a plunger pump. There is a positive feed engine-lubricator built at Rochester, New York, that comes pretty close to the mark we are aim-

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ing at, except that as at present built and marketed, it is not exactly suitable. In the mechanical essentials, however, it is what we want. I have been in correspondence with the London Agents to see if the Company would build the lubricators modified to meet our requirements. The matter was taken up with the manufacturers in Rochester, but they have expresesd a disinclination to bother with the business. We will probably have to design and build our own apparatus of this sort.

DRY TAILINGS. The preparation and feed of dry tailing has been worked out in different ways at Broken Hill, notably at the Minerals Separation plant, the Zinc Corporation, the Proprietary and the de Bavay plant.

The operations to be performed in each instance are:

a. The excavation of material.
b. The transportation of material to the plant and delivery to the ore bins.
c. The feed of material to the regrinding section, if such is required.
e. Regrinding.
f. The preparation of the reground material for the mixers.
g. Delivery to the mixers.

a. *THE EXCAVATION OF STACKED TAILINGS.* There are two general methods of doing this. One is by hand, and the other by machinery. In general, it can be said that excavation by machinery is performed with maximum economy, when the excavator is

running full capacity and full time. The crew per shift is approximately the same for any reasonable tonnage. In the case of steam shovels, of course, an average of more track layers, and men in train crews is necessary when large tonnages are being handled than with small tonnages, but such charges would be very nearly constant tonnage charges, increasing slightly per ton, however, as the tonnage handled was reduced.

A steam shovel can be worked with fair economy when it can be kept going steadily for a full shift. In the case of excavating a tailings heap by steam shovel, the amortization charges would be spread over the whole tonnage, which is a definite amount, whether that tonnage were excavated in two years or ten years. The tonnage charges for amortization would be increased somewhat in the case of a longer period, by the interest charges on the unredeemed amount. An example will make this clearer.

Assume 1,000,000 tons.

At 850 tons per day for 300 working days this will last say 4 years. If we assume our excavating plant costs £2000, and if we amortize at 5% we will have to charge £564 each year against the tonnage to take care of our interest. This is .54d per ton.

At 333 tons per day the dump would last 10 years, and we would have to charge out £259 per year for amortization or .62d per ton. These are, of course, insignificant amounts, but they serve to illustrate the statement. If the tonnages available and required are

not such as to permit of a full shift's work each day with the machine, economy falls off rapidly.

At the B. H. Proprietary plant an average of between four and five men per shift are required for operating the steam shovel and attending to the track. Besides these, three or four men are required for looking after the conveyors, etc. They thus require nearly the same number of men per shift to excavate the Proprietary Co.'s tailings by steam shovel, as is necessary to excavate the tailings for the Mineral Separation Company by hand and get them to the bins. As mechanics are paid a higher rate than shovellers, and as a steam shovel requires coal, oil, water and repairs besides the labor of operating, it is quite plain that hand shovelling is the cheapest method up to very considerable tonnages. In general, then, we can conclude that in practically all cases hand shovelling will be the cheapest. I do not know of any other very large tailings heaps, like the heaps at Broken Hill, that we are apt to find important to us. In cases where there are less than a million tons, it is not worth while figuring on a steam shovel. I can conceive of mechanical appliances being developed along other than steam shovel lines, in such a way as to make it profitable to mechanically excavate smaller dumps than can now be handled, but that is another matter.

The best method of transporting tailings from the pile to the treatment works will have to be worked out in each individual case. Depending on the location of the treatment plant with reference to the dumps, different

means of transport will work out as the cheapest for different locations of plant. Thus, the Zinc Corporation has found, that, for certain dumps the most economical method is to shovel into ordinary mine cars and dump these into railway trucks, in which the sands are transported to the plant. For treating the South Mine tailings, however, they have built an aerial wire rope tramway, as the situation of the dump relative to the works is such, that such a tramway works out as being the cheapest means of transportation. On the other hand, the transportation by the small cars into which the tailings are shovelled, from the dump to the bins, is unquestionably the cheapest way of getting the Minerals Separation tailings to the plant. The Proprietary has worked out a system of belt conveyors and bucket elevators as being the best for their needs, and, for the tonnages they handle, I presume it is.

We cannot then choose any particular system of transportation as being the best for all cases, for it will not be. Each individual case will furnish its own variation of the problem, and will have to be worked out separately. Neither could we usefully discuss the characteristics of the different methods, for the weight to be given to the different variations will be different for the different cases.

ORE BINS. The factors controlling the design of ore bins are the cost of erection, and the cost of operation as it may be affected by the design. In cases where the mill site is on a good sidehill location, there will not

be much chance for variation of the bin design. Where a treatment work is being erected on a flat, however, a number of variations are possible, and these work out as follows: Of the various possible types of ore bins, a bottomless bin in which the ore would be filled in directly on the ground would require the least timber for construction. This sort of a bin would consist merely of four walls, properly tied together with rods. One having a total capacity of 500 tons, with a run out capacity of 175 tons, at a point conveniently high for the ore feeders, or say five feet above the ground, would require 12,000 super feet of Oregon timber and lumber for its construction, on the basis of a safety factor of 6.

If instead of building a bottomless bin we would build one with a flat bottom at the point we have located the feeders, or five feet above the ground, we would need, using the same safety factor, about 15,000 super feet of lumber. This bin would have a total capacity of 385 tons and a run out capacity of 175 tons. If instead of a flat bottom we have a bottom sloping 45%, and the feeders at the same point, we would have a total and run out capacity of 180 tons, and 13,000 super feet would build the bin. A flat bottom bin of the same capacity as before, elevated 20 feet above the ground on posts, would require 24,300 super feet to build it. A sloping bottom bin for 175 tons capacity at the same height, would require 19,500 super feet.

ORE FEEDING DEVICES. There are a number of different ways in which dry tailings can be fed out of

an ore bin, and several of the devices manufactured are capable of a wide variation of adjustment and are good dependable machines. If means are taken for eliminating stones, rubbish and pieces of iron from the tailings, the Challenge Feeder is about the neatest and most effective of the various devices of crushed ore and tailings.

For feeding tailings that have not had metal and trash removed, the Push feeder as used at the Minerals Separation plant and at the Proprietary is a good device, except that the punched plate in each feeder is not a good substitute for an independent screen taking the whole feed. When a plant is working on dry tailings a good regulation of the feed is easier to get than it is when the flotation section is working on current tailings from previous treatment.

For a large plant we might have Challenge feeders delivering tailings to a conveyor belt running in front of the bins. The conveyor belt would be equipped with a continuous weigh bridge and would deliver to the grinding section. For smaller plants, Challenge feeders in front of which pans on spring balances could be swung for weighing portions of the feed at definite intervals, would be a good arrangement.

In ordinary cases tailings would have to be reground for Minerals Separation work and a comparison of different forms of regrinding apparatus is useful. The determining factors in such a comparison are the efficiency of regrinding and the cost of regrinding. In a large

P. 1180, L. 8, insert "on the market for regulating and controlling the feed" after "devices"

sense the latter includes the former. The following comparison will be restricted to two types of apparatus, the pan and the tube mill.

I have no comparative data bearing on the value of the Chile Mill as a regrinding machine for our purposes. On account of the growing scarcity of flints for tube mill work, however, the Chile Mill will become of larger relative importance in the future.

Pan grinding in Broken Hill has four different variations. There is positive grinding with 5 foot diameter, and with 8 foot diameter pans, and classifying grinding with the same sizes. By positive grinding is meant feeding the pan in such a way that the only escape for the material is between the grinding surfaces. In the pans which are usually used for grinding the oversize from the screens, the discharge of the pan is set higher than the discharge from the grinding surfaces. This keeps a considerable body of pulp in the pan and results in a classification of the material before discharge, much of the coarse staying in until it is reground.

At the Minerals Separation plant there are twelve 8 foot diameter pans. As between these and the 5 foot diameter for efficiency, we have practically a direct comparison with the Zinc Corporation work. The grinding at the Zinc Corporation is a little coarser, hence, with equal, or lower costs at the Minerals Separation, the comparison would be in favour of the 8 foot pan as against the 5 foot.

From the reports of the Sulphide Corporation the

total cost of regrinding for the last half of 1909 with 8 foot pans was 13.836d. per ton in the Minerals Separation plant and 13.452d. per ton in the Lead Mill. In January, 1910, a normal month, the cost of regrinding at the Zinc Corporation with 5 foot pans was 17.54d. per ton. At the South Mine the cost of regrinding with 5 foot pans for the last half of 1908 was 17.1d. per ton. The Broken Hill Proprietary furnished me with their costs of pan grinding with the 5 foot machines, and their figures total 24.87d. per ton.

Of course none of the pans were working on identical material nor were they working under exactly parallel conditions, nor is it likely that the costs were arrived at in the same way, but in spite of all these possibilities for discordance in the comparisons, there is enough margin between the costs we have, to indicate quite definitely that the larger pan does the cheaper grinding. This is an item to the credit of the management of the Sulphide Corporation, for having adopted the larger pan.

At the South Mine, the cost per ton of regrinding with a 4½x13 foot Krupp tube mill for the last half of 1908 was 9.02d. per ton, as compared with 17.1d. per ton for 5 foot pans on the same material. At the Broken Hill Proprietary the cost of regrinding with a 10′x5′ tube mill was given me as 11.15d. per ton, compared with 24.87d. per ton for 5 foot pans on the same material. At the North Mine it was stated to me that the 5′x10′ tube mills took about three quarters of the power required by the pans, for the same tonnage, and did better work.

Complainants' Exhibit—Nutter Report
December 3, 1910.

To my mind there is no doubt but that the tube mill is less sensitive to fluctuations in feed, is more easily kept in adjustment, is more dependable, and more nearly fool proof. On the basis of my own experience alone, with pans and tubes, I would have very little hesitation about installing tubes, for practically all fine grinding work. The sliming done, depends on the length of time the material stays in the tube, which is a function of the length of the tube and of the rate of flow of pulp through the tube. At Broken Hill it has been found that the 10′x5′ tube turns out the best work when it has a rather dilute feed. Under these conditions, it makes about the same proportion of slimes as the pans, is easier to regulate, and cheaper to instal, for the same tonnage capacity.

TABULATED COMPARISON.

Charge	M.S. 8 ft. pans.	S.~~S~~G. 8 ft. pans.	Z.C. 5 ft. pans.	S.M. 5 ft. pans.	Prop. 5 ft. pans.
Labour & salaries	2.772d,	1.812	2.69	.9	.90
General Supplies	.84		3.97	.1	12.70
Water	.372	.252	1.11		
Power	5.928	6.444	6.17	11.0	7.50
Rep. & main	3.528	4.704	3.35	5.1	3.77
Samp. & Assay			.23		
Sundries	.384	.216	.02		
Total cost per ton.	1/1.836	1/1.452	1/5.54	1/5.1	2/0.87

Complainants' Exhibit—Nutter Report
December 3, 1910.

I think it can be assumed, then, that for fine grinding the tube mill is for most cases the better and more economical of the two devices. This would not be true of course in cases where the tube mill could not be run at its full grinding capacity. After regrinding, the pulp can be screened or classified, and of these, screening is technically the best. As commercial screening of large tonnages is done wet at Broken Hill with the local variations of the King screen of sizes down to .25 mm. corresponding to ordinary 50 mesh cloth, such screening does not offer the difficulties it did a few years ago. From this point onward, the treatment would be much the same in all the cases depending on the vagaries of particular ores.

We come now to the question of actual treatment and what is the best form of agitator, mixer, separating box, etc., to use.

The answer to this question varies with the terms of the problem. The terms of the problem are controlled by the nature and characteristics of the ore and the results aimed at. Thus if we have a heavy sulphide ore containing several different minerals which have to be separated from each other, before their full value can be realised, our investigation and testing will naturally follow a different procedure, than it will in the case of an ore containing a relatively small amount of a single valuable mineral. We are always aiming at a maximum extraction of £. s. d. from the ore. In one case this may mean a maximum extraction of the mineral with a high-

P. 1184, L. 31, insert " valuable mineral ; in another a lower extraction of the " before " mineral "

er grade of product; in another, a good extraction of one mineral, at the expense of a poor extraction of another, and so on. In other words, the commercial requirements are always the dominant factors.

Several types of plants have been designed for the treatment of ores by Minerals Separation process. Of these the type that was first installed at Broken Hill at the central Mine, has served its purpose and is obsolete. A newer type designed by Mr. Hoover is such a decided improvement that for ores and treatment conditions giving a stable froth, and where differential flotation or flotation sizing is not a desideratum, it does the work as well as could be required.

A Third type outlined by myself in consultation with Mr. Hoover has been under trial at Charlotte Street with promising results. A new plant has been designed along these lines, and is being built, and will be tried out in the course of the next few weeks.

I am inclined to think that one of the most important mechanical lines for investigation is that of a threshing out of the possibilities of plus pressure apparatus. I have been giving this considerable thought, but so far am ready to design in detail only a single type of apparatus. I have rather held this in abeyance, until we find out the possibilities of the new type of separating boxes.

The disposal of tailings and concentrates will in all cases form local and special problems.

Complainants' Exhibit Letter Minerals Separation to Hyde, November 23, 1910.

MINERALS SEPARATION AMERICAN SYNDICATE Limited.

62 London Wall,
London, E. C. 23rd Nov. 1910.

Dictated to M. E. P.
By J. B.
Enclosures 2

James M. Hyde Esq.,
c/o Bruce Mines Ltd.,
Bruce, Ontario.

Dear Sir,

BRUCE MINES. Last night we received your cable of same date, turning the proposition down as unsuitable for our purposes, and thank you for your prompt decision. We at once replied authorizing you to visit the other properties in the vicinity which you had in mind.

CABLES. We enclose confirmatory copies of cables that have passed between us, viz.

Cables received from you on the 17th and 22nd and our replies of the 22nd and 23rd.

G. W. THOMSON—COBALT. We enclose you copy of letter received from that gentleman by our Chairman, dealing with the Zinc lead Silver property near Ottawa. We cabled you to-day to get into communication with Mr. Thomson, and we also cabled him to send you all particulars, from which, when received, you will

Complainants' Exhibit—Letter Minerals Separation to to Hyde, November 23, 1910.

gather whether the proposition is worth a visit. If so, please examine closely and find out whether business is possible on our lines—if not waste no time over it.

Mr. J. H. Curle has been detained here, but will in all probabilities leave for New York in a week's time, and will endeavour soon to come into touch with you, it being the resolve now to pay more direct attention to the U. S. A. and Canadian business, and to leave Mexico in abeyance for a time.

THE WHITE MOUNTAIN MINE. From information given him, Mr. Hoover gives the following particulars—

"The White Mountain Mine is near Hancock, Michigan. The ore is supposed to carry 4% metallic copper and has hitherto been difficult to treat because of the fine dissemination of the copper through a sandstone gangue. The mine has been shut down for years, but there is said to be a thousand tons of the ore in the bin. We would like to have a few hundred weight of this ore for testing and research. Frank Klepetko of 42 Broadway has full information about this property and a report by him, made some time ago, could be secured for probably $150. Alexander Hamilton, Sydney, an attorney of Detroit is one of the principal share-holders. The shaft is said to be 400 feet deep."

After attending to the above matters, please proceed to Butte, Montana, and there go into the Zinc situation with the same minute care which has attended your investigations of the various fields in Mexico. Also test the tailings and various products you can secure from

the copper mines and mills, saying as little about your connection as is consistent with getting information.

After Butte, it is our opinion now that you should proceed to Virginia City to look over the silver tailings there, and then perhaps to Ely, Nevada. These two latter points, however, are subject to alteration if it seems advisable.

We are, dear Sir,

Yours truly,

John Ballot

For and on behalf of

Minerals Separation American Syndicate, Limited.

Complainants' Exhibit Cable Minerals Separation to Hyde December 8, 1910.

CANADIAN PACIFIC RAILWAY COMPANY'S TELEGRAPH.

Via Toronto

From London, 8 Dec., 1910.

To Jamehyde,

Sudbury, Ont.

ugparzuow	Re your wire of 7th Curle
tubogjouhb	still in
klehzuzfop	movements uncertain
epgemakdra	Do not alter
wuselosjog	your present
okonb	program

Complainants' Exhibit, Cable, Hyde to Minerals Separation, December 9, 1910.

Cable to Mineration via Ottawa, Dec. 9, 1910.

Jierc	——	re your letter of the ~~34~~23rd ult.
ugpes	——	re your telegram of the 8th
wueng	——	you are
atybe	——	fully aware that
hyawm	——	I would not
divco	——	contract for
kitya	——	more than
layne	——	one
wubar	——	year
guacf	——	.
huyob	——	I shall be
kukib	——	New York
ebbre	——	in a few days
uhkun	——	telegraph to me
ukphe	——	there
huded	——	how
alavk	——	and
wecky	——	when you
olgel	——	propose to
anuzk	——	arrange for
guety	——	future
woirg	——	work

Complainants' Exhibit Hyde Report, January 8, 1911.

THE NORTH AMERICAN SITUATION

The situation with regard to the possibility of doing business in North America, in so far as it has been possible to consider it during the past year, is in substance as follows:

MEXICO.

ZINC SITUATION

The work carried on in the Mexican field has demonstrated that the Mexican Zinc situation appears to offer promise of furnishing a piece of business of large possibilities as to profit, providing that it is possible to dispose of the Mexican Zinc ores and concentrates at substantially better prices than those now offered by the European smelters, or to smelt the same at a profit in Mexico, and also that the business entered upon and contracts for the ore, leases of properties and options on mines be negotiated before one of the several corporations now striving to enter the field manages to get the cream of the business.

My sudden departure from the field, before it was possible to canvass the zinc situation sufficiently thoroughly to enable me to submit a detailed and comprehensive report on the whole situation, leaves the matter, in so far as my information is concerned, practically where it was when I wrote from Parral giving an outline of the method by which the situation might be met, with the single exception that a closer inspection of the general smelting situation has revealed that the rise of

Complainants' Exhibit—Hyde Report,
January 8, 1911.

the modern silver milling practice in Mexico has so greatly reduced the tonnage of siliceous silver ores now going to the customs smelters as to make the entry in general customs smelting work hazardous. The field for customs milling plants for mixed sulphide ores, and a zinc smeltery, with annex for treating its own valuable residues, appears to be sufficiently promising to warrant a completion of the investigation which I was carrying on, providing the American Syndicate cares to consider the possibility of entering into the business of zinc smelting in Mexico.

The American Statistics show that in spite of the very high protective tariff of 1c per lb. on zinc in ores carrying over 25%, over 100,000 tons of zinc ores (principally "calamines") were imported from Mexico into the United States in the year 1909.

In many districts of Mexico zinc sulphide and calamine occur in quantity but have no market value under present conditions. As a consequence these ores can now be contracted for, or the mines purchased, at extremely reasonable terms.

The ore from the Tajo Mine at Parral, which is now en route to Your London works, will throw much light on one of the most critical of Mexico's present metallurgical problems. Argentiferous ores of this type occur in many parts of the republic and are of little or no value under present conditions.

COPPER SITUATION

My own tests offered very little hope of dealing satis-

factorily with the chalcocitec copper ores of the Sonoran region. The tests which have so far been carried out in your London laboratory upon the samples sent from Cananea, Clifton and Morenci, have not given promise of success. It is possible that some combination of flotation work with the preliminary use of a soluble alkaline sulphide or hydrogen sulphide may solve this problem by coating these very fine particles of chalcocite with a film of the floatable mineral covellite. When opportunity arises, this subject should be given the most careful study possible, as the copper ores of a good part of the Southwest and also of at least a portion of the Utah region contain chalcocite which is not floatable by any of the methods so far tested.

The tonnage of ores of this type handled is very large and these ores should yield a considerable revenue in the form of royalties, if they could be treated by any cheap modification of the flotation processes.

The tests upon the Vanner feed and slimes tailings from Nacozari were very promising. Larger tests should be carried out on these, either at the London works or at an American Tests Works, when established, as it is very probable that a profitable piece of business can be done with Phelps Dodge & Co., so soon as your royalty policy with regard to American business has been defined and the final tests made on this material. There are many reasons other than mere additional saving which would incline these people to install a flotation unit in the place of their Vanner room.

From information obtained from engineering friends,

P. 1193, L. 26, insert " copper situation, the British Columbia " before " lead "

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it seems possible that the ore of one or more of the mines of the region west of Guadalajara might possibly be advantageously treated by flotation, but the region as a whole is not particularly promising. I did not have the opportunity to visit the district.

The most promising copper district not visited by me is in the State of Michoacan. I am expecting full data with regard to a seemingly promising proposition in this state to reach me soon after I get an American headquarters established. A friend in Mexico has considerable data concerning it.

There are also a number of districts in Southern Mexico which contain mixed sulphide ores which are worthy of investigation.

I am now so familiar with the territory and my impressions are so fresh with regard to it that I deem it advisable to have a competent assistant working under my direction cover those promising portions of the country which I could not visit. This could be done with comparative rapidity if no attempt to make tests in the field were to be made.

CANADA

The Canadian situation may be considered under the following heads, the British Columbia, lead zinc situation, the Georgian Bay Copper District and the Sudbury Nickel district. With the exception of isolated occurrences of Molybdenite and graphite these regions are the only ones known of at the present time which seem to offer any opportunity for flotation processes.

Complainants' Exhibit—Hyde Report,
January 8, 1911.

THE BRITISH COLUMBIA COPPER SITUATION.

Both in the Rocky Mountain region and along the coast of British Columbia deposits of disseminated chalcopyrite occur. Some of these are said to be of large size and much promise. More data will have to be gathered concerning th~~o~~ese deposits before it can be decided definitely as to whether or not they are of sufficient promise to warrant putting an assistant at work to investigate them during the coming summer.

THE BRITISH COLUMBIA LEAD ZINC SITUATION.

In the Rocky Mountain district of British Columbia mixed ores of lead, zinc and silver occur. These have been made the subject of special study by the Department of Mines of the Dominion Government, which has issued a comprehensive report upon them by Mr. Walter Renton Ingalls and Phillip Argall. An investigation is now being carried on as to the possibility of smelting the zinc ore locally. A sum of $50,000 has been voted by the Dominion Parliament for this work.

This situation should be studied carefully, it is possible that it may offer some opportunities for the American Syndicate, but the field has not heretofore been considered of especial promise, because of the scattered nature of the ores and the heavy transportation costs.

GEORGIAN BAY COPPER DISTRICT.

There are a number of chalcopyrite bearing quartz veins of the Bruce Mines type in a district probably

Complainants' Exhibit—Hyde Report,
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forty or more miles wide by perhaps one hundred miles long lying along the northern shore of Georgian Bay.

The best developed and best known of these are the Superior Copper Mine, forty miles north of Sault Ste. Marie, Ont., on the line of the Algoma Central R. R., the Bruce Mines, the Hermina Mine near Walfort Sta., and the Massey Mine near Massey, Ont. In addition to these there are the Moose Lake prospects, the Cheney Mines about 20 miles north of Bruce Mines, the prospects in Desbarats location, not far from Bruce Mines, the Copper Queen Mine in Moran Toop, 24 miles north of Bruce Mine and a property owned by Frank Klepetko and associates. I am informed that there are several more concerning which I have no definite data at the present time.

The Massey and Hermina Mines are connected to the Canadian Pacific Railroad by short spur lines and are also within a few miles of shipping facilities on Georgian Bay.

The Moosehead Lake Mine is but a few miles across level country from both the Canadian Pacific Railway and Georgian Bay.

Some of the other properties are near transportation facilities and others are 15 to 25 miles back in the woods.

I am informed by reliable engineers that it is probable that a considerable tonnage of ore running 3% in copper can be obtained from a number of these properties.

The Hermina, Massey and Superior Mines are suf-

ficiently developed to allow of fairly satisfactory examination. They are white elephants on their owners hands and can probably be obtained by lease or purchase, or for stock in a new organization, on reasonable terms.

The less developed properties can undoubtedly be obtained on very reasonable terms. The price asked for the Moosehead Lake is but £3,000, to be paid in three equal installments.

When I was in this district the ground was so covered with snow and the conditions affecting travel and work were such that it was not then wise to try to gather much data concerning these properties. These conditions made my trip to the Superior Mines rather disappointing.

The district is sufficiently promising to warrant careful investigation during the coming summer. Mining and shipping costs should be especially low.

I have filed with you all the reports which I have been able to secure with regard to the Superior Mine and the Moosehead Lake property, and will supply your office with other data as I receive it from various sources.

SUDBURY NICKEL DISTRICT.

The world's production of nickel comes almost entirely from two sources—the nickel silicate deposits of New Caledonia and the pyrrhotitic nickel-copper ores of the Sudbury District of Ontario.

The nickel business of the world is now in the hands

of a trust which has made enormous profits out of its exploitation. The demand for nickel is increasing so rapidly that the Companies operating in the Sudbury district are constantly adding to their equipment of furnaces and increasing their output. The deposits of this region are of a peculiarly definite character, the nickel occurs in great masses of pyrrhotite and calcopyrite which has segregated out of the basic portion of a volcanic intrusion. Deposits of greater or less volume are found around the edge of this intrusion throughout its known area.

The working of these mines is a venture of very unusual safety for a mining business, as the deposits are large and continuous and the amounts of copper and nickel contained are sufficient to give the ore a relatively high value per ton. The metallurgy of these ores is extremely simple. The crude ore is mixed with a small amount of quartz and lime and from 10% to 17% of coke, and smelted semi-pyritically in blast furnaces. The matte from these furnaces is raised to about an 80% total content of nickel and copper in Bessemer Converters; the high grade matte is sent by the Canadian Copper Company to the U. S. for refining, and by the Mond Nickel Company to England for refining. Both of these concerns have made extraordinary profits from their enterprises.

There are a number of known deposits of large size in the district, which have not yet been opened up on a commercial scale. It is possible that from among these could be gathered together at a reasonable price, a sufficient

number of mines of assured tonnage to warrant entering into the business.

The Lake Superior Corporation of Sault Ste. Marie, Ont., owns a number of properties of great promise. They have by diamond drilling proved to their own satisfaction the presence of at least 500,000 tons of ore in properties which they control, a large part of which is by their statement of as good a grade as any that is being treated by the Companies now working in the district. The Lake Superior Corporation has become involved in so many large enterprises, which require all the capital which it can command, that it is desirous of disposing of its copper-nickel holdings. These are now under option to people in Chicago and a decision in the matter will be reached with these parties within the next 60 or 90 days. As the same people have previously dealt with them without being able to conclude the business, it is very possible that this property will be obtainable at a reasonable figure on time payments or for shares in a new company which will agree to find all capital necessary to develop the mines, treat the ores, and sell the products.

There are also a number of other known deposits of considerable promise, which are obtainable, and there are a number of tracts of swampy ground which could be prospected at small cost, which seem to offer considerable promise.

Around the edges of the bodies of heavy sulphide ore is considerable ore of a lower grade, which consists of portions of the basic rock impregnated with sulphides which in settling did not reach the mass of solid sul-

phides. Up to the present no attempts at concentrations have been made in the district, and ore of too low grade to smelt at once has either been left in place or thrown upon the dump. Apparently all of the sulphides which are valuable ~~available~~ in this ore are easily recoverable by flotation methods. I am having a small sample of these ores tested in the London works.

I submit independently a number of letters and reports bearing upon this topic. When I have sufficient data to guide me to a final opinion as to the possibilities in the matter I will ask you for a decision as to whether or not you wish to undertake an enterprise of this type in which the flotation processes are likely to be a contributing factor of not very great importance. From many standpoints, the business seems to be a most unusually promising one. The amount of capital required to put the matter on a proper basis and give it sufficient working capital would probably be from £200,000 to £400,000.

UNITED STATES OF AMERICA.

DISTRICTS.

Among the districts of promise in the United States are the following:

The Butte district of Montana in which large deposits of zinc sulphide ores, needing concentration, are being developed and in which are being mined and concentrated an enormous tonnage of sulphide copper ores which if amenable to flotation treatment should offer large possibilities of royalty business.

The disseminated copper ores of the Bingham Canon

District of Utah, the Ely District of Nevada and a number of districts of Arizona and New Mexico in which occur such well-known mines as the Miami, Ray Consolidated, etc., are being handled on an enormous scale. In a number of these districts the very fine chalcocite occurring in the ores may offer a considerable difficulty to flotation treatment, but in others it is possible that the sulphides are of such a nature as to be readily treated by flotation methods. These districts may yield a considerable volume of royalty business, and may possibly present opportunities for independent ventures.

The mixed sulphide ore region of Colorado and other portions of the Rocky Mountains, seems to be of great promise. Properties in the San Juan district, Colorado, are already under consideration and should be investigated carefully during the coming season.

The Comstock Lode region at Virginia City, Nevada, contains some very large deposits of tailings from silver sulphide ores, and is also said to contain a considerable tonnage of low grade sulphide ores in place. As the concentration of ores of this type in the Yellow Jacket mill has resulted in a recovery of 80% of the gold and silver contents in a pyrite concentrate it seems quite possible that flotation methods might be used here with considerable success. A contributory factor of possible large advantage is the fact that a very considerable volume of hot acid water is produced by these mines and flows in immediate proximity to the old mill tailings, dumps. No examination of these tailings can be undertaken to advantage until the winter snows have thawed.

Complainants' Exhibit—Hyde Report,
January 8, 1911.

HEADQUARTERS.

A careful study of the whole situation throughout the year has led to the conclusion that the best place for a headquarters for the campaign both for the executive office and for test works, is Denver, Colo., or Salt Lake City, Utah, both of which are very centrally located from a mining standpoint. Work on the field may indicate that some other point will naturally become the center of activities through the first investigations being begun there and the first equipment for test purposes being erected to take care of some local enterprise. A large part of the business transactions will probably have to be carried out in New York City but it is probably much wiser, for the present at least, to keep the head quarters of the work at the centre of its activities in the heart of the mining districts. If the venture is successful in a large degree it is quite possible that it may be wise to have its headquarters transferred to the financial capital of America later on.

ASSISTANTS.

The territory in America requiring attention is so large and the deposits of possible interest are so scattered and of such varying nature that it will probably be advisable, in view of the fact that it is well to cover the field as rapidly as possible, to make use of several trained assistants investigating different districts under the direction of the General Manager.

Complainants' Exhibit—Hyde Report,
January 8, 1911.

TEST WORKS.

The past year's experience has demonstrated that very little, if any, test work should be undertaken in the field, and that so soon as it is possible to do so to the best advantage, a centrally located test works should be equipped at which tests on both a large and small scale can be made. It is quite possible that some small concentrating mill, or possibly a plant which has been used as a public test works, which is conveniently located upon a railroad, may be leased on reasonable terms, and equipped at small expense to give all the facilities that are needed for this work. If that can be done, it will be better policy to follow such a course than to go to the capital expense and loss of time necessary to erect a special works for this purpose.

At the present time it seems wise to investigate the Butte district first, as that is the region of greatest apparent promise and in which it is probable that results can be most rapidly attained.

8/1/11 JAMES M. HYDE.

Complainants' Exhibit Copy Memorandum re Managership of Minerals Separation American Syndicate, Limited.

MEMORANDUM RE THE MANAGERSHIP OF MINERALS SEPARATION AMERICAN SYNDICATE LTD.

The mining fields of the North American Continent are of great extent, varied nature and vast possibilities. They offer great opportunities for the exploitation of the Minerals Separation Ltd's patented flotation processes.

There are three factors upon which the success of ventures of the class being undertaken depends—the processes, the capital with which to exploit them, and the executive and creative business capacity of the manager.

The position of manager of the Minerals Separation American Syndicate Ltd. involves great responsibilities and the most varied and most taxing variety of duties and functions which will have to be exercised in connection with reaping the possible advantages of flotation processes. The success of the venture will be contributed to as largely by the capacity of the manager as by any other factor. It will in fact be absolutely dependent upon his scientific knowledge, technical experience, adaptive ability, and creative and executive capacity. Anyman possessing such abilities must be fully conscious of his qualifications and powers and of their commercial value. No man possessing such capacity will consider investing his energies in enterprises in which he is not adequately compensated for his time, and also allowed to create for himself an estate, by a just participation in the results of

Complainants' Exhibit—Copy Memorandum re Managership of Minerals Separation American Syndicate Limited.

his labors. No mere salary, or salary combined with any terminable form of profit sharing can adequately compensate such a man for the expenditure of his business-creative ability.

In order for the position of manager of the Minerals Separation American Syndicate to be acceptable to me it would have to carry the following considerations.

1st. The manager should be empowered to draw up and carry out the plan of campaign, to hire and discharge employees necessary in the work, to instal testing facilities, when desirable (in connection with the Minerals Separation Ltd's technical staff), to conclude leases and options on properties, or purchase raw materials where such transactions do not involve an expenditure or obligation of more than a certain fixed sum, say £1000, it being however understood that whenever reasonable (and no delay being thereby caused to the Syndicate in the Manager's opinion) authority should be obtained from London for all transactions involving cash payments or obligations exceeding £500.

2nd. The position should not be considered to be subordinate to any appointive officer of Minerals Separation Ltd.

3rd. The salary should be such as similar engineering and business service usually commands and in no case less than is received by any other technical man connected with the exploitation of the Minerals Separation Ltd. processes.

4th. As partial compensation for creating the Ameri-

Complainants' Exhibit—Copy Memorandum re Managership of Minerals Separation American Syndicate Limited.

can business the manager should receive a two years free option upon the right to subscribe at par, or issue price, to ten per cent of the capital stock of the Minerals Separation American Syndicate, and all business resulting on the American Continent from the use of the Minerals Separation processes or contributed toward or undertaken by the Minerals Separation Ltd., the Minerals Separation American Syndicate Ltd. or any offshoot from them launched during the term of office of the manager.

5th. All mining and milling propositions of sufficient promise shall be submitted to the directors for their consideration. The manager shall be considered at liberty to deal in his own interest as he may see fit, with any proposition not considered as desirable as a Minerals Separation American Syndicate Ltd. venture by the Board of Directors.

6th. There shall be a regular and prompt consideration of all communications submitted to the London office, and some official or officials shall be designated to regularly inform the manager of the results of such consideration, and to discuss the matters treated of in such communications with him.

Complainants' Exhibit Letter Hyde to Minerals Separation American Syndicate, January 17, 1911.

62 London Wall, London, E. C.
17th January, 1911.

Mr. John Ballot,
Chairman, Minerals Separation
American Syndicate Ltd.,
62 London Wall, City.

Dear Sir:—

I hereby withdraw the "memorandum re the managership of the Minerals Separation American Syndicate" which I placed in your hands a few days since. I have determined that it is not wise for me to contract with your Company for another year.

I have in my possession a variety of articles used in my work which were purchased with the funds of the Mexican Syndicate. These I will turn over to whomsoever you may indicate. A portion of them are now in London, others are in my trunk in New York, while others are packed with some of my personal effects in a box stored in Canada.

My expense account, when presented, will include the cost of my return to California.

It is possible that while engaged in exploratory and metallurgical work in the United States, I may have opportunity to use a flotation process, or to recommend the adoption of one by some ~~big~~ going concern. Will you kindly inform me as to the royalty you have decided to ask in America and the commission you are willing to pay on royalty business brought to you.

Respectfully yours,

JAMES M. HDYE.

Complainants' Exhibit Letter Minerals Separation to Hyde, February 1, 1911.

MINERALS SEPARATION AMERICAN SYNDICATE Limited.

62 London Wall,
London, E. C. 1st Feb. 1911.

Dictated to M. E. P.
By J. B.

J. M. Hyde Esq.,
c/o H. C. Hoover Esq.,
1 London Wall Buildings, E. C.

Dear Sir,

In further reference to your letter of the 17th ult. and as personally explained on several occasions, I regret that you have decided not to extend your engagement with our Company for another year.

With regard to the various articles belonging to the Company in your possession, I shall be pleased, as already arranged between us, if you will have these delivered to Messrs. Beer-Sondheimer & Co. of New York for our account, and they will pay any expenses for freight, forwarding etc. thereon. We believe they have an agency at Salt Lake City as well, and so soon as we get the address from them, we shall be glad to forward it to you, should that centre be more convenient to you.

As you say, it is possible that while engaged in exploration and metallurgical work in the United States, you may have the opportunity to use our Flotation Process, or to recommend the adoption of the use of same to some

going concerns. We wish to assure you that we shall be glad to consider any such business proposals on their merits as they come along, when the question of terms, either by royalty or otherwise, and also your commission for the introduction thereof, will be gone into at once and mutually arranged.

I am, dear Sir,

Yours truly,

John Ballot,
For and on behalf of
Minerals Separation Limited.

Complainants' Exhibit Extract From Richards' Ore Dressing.

Sec. 869. *Settling Fine Slimes by Means of Dissolved Substances and by Heat.*

In sampling mill products that contain slimes carried in water it should be remembered that the extremely fine particles may not settle in several days or even weeks. However, there are various substances, small quantities of which dissolved in the water will coagulate the particles into comparatively ~~small~~ large grains, which settle rapidly. Such a substance should be used in every important case, for the fine slimes are apt to contain a large percentage of the *value,* although they may be very small in *weight.* At one mill where the samples were allowed to settle only a short time before pouring off the water, assays of the tailings indicated 8 to 8½ ounces of silver per ton, but

P. 1209, L. 21, insert "Suspended matter, the extreme variation being from 12.3%" before period (.)

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Complainants' Exhibit—Extract from Richards' Ore Dressing.

when the slimes were thoroughly settled, the tailings assay was found to be 18 ounces of silver per ton.

The following experiments, made in the author's laboratory, give some exact results with the use of lime, alum, common salt, hydrochloric acid and sulphuric acid. The slimes were obtained by stamping a quartz ore from North Brookfield, Nova Scotia, containing some slate, a fractional percentage of arsenopyrite and some free gold, using a punched screen with slots 1/40 inch wide and a height of discharge of 4 inches. After passing over amalgamated plates and a vanner, the coarse portion was settled out in small tanks, while the finest slimes were carried into a larger tank from which the water was pumped back to the stamp mill and used again. After the mill run was finished and the water had remained quiet in the large settling tank for half an hour, a large sample of the slimy water was taken from the top of this tank. Fifteen careful tests showed an average of 12.8% to 13.0%. The results, given in Table 394 are based on this average. The tests were made on one liter quantities in beakers of such size that the water stood 6½ inches deep in them.

Complainants' Exhibit—Extract from Richards' Ore Dressing.

TABLE 394.

EFFECTS OF DISSOLVED SUBSTANCES IN SETTLING FINE SLIMES.

The figures below show the per cents. of total slime settled out, by the use of different per cents. of dissolved substances in different periods of time.

Time of Settling.	Nothing Added	Common Salt. ½%	1%	2%	5%	Ammonia Alum. ½%	1%	2%	5%
½ hour	22	89	99	100	100	97	98	....	91
3 hours	72	98	98	100	98	100	100	100	....
14 hours	....	100	100	100	100	100	100	....	....
15 hours	....	....	....	....	....	....	....	....	....
20 hours	94	....	....	....	....	....	....	....	....

Time of Settling	Potash Alum. ½%	1%	2%	5%	CaO Present After Adding Lime Water. .00305%	.00595%	.01136%
½ hour	99 (?)	94	98	95	77	95	98
3 hours	99	99	94	96	91	100	100
14 hours	100	....	100	....	....	....	....
15 hours	....	....	....	....	100	98	100
20 hours	....	....	....	....	....	....	....

Time of Settling	Continued: CaO Present After Adding Lime Water. .02083%	.02885%	.04167%
½ hour	100	100	95
3 hours	100	100	98

P. 1210, erase from line 16 to p. 1211, line 3, and substitute

Potash Alum

Time of Settling.	½%	1%	2%	5%
½ hour	99 (?)	94	98	95
3 hours	99	99	95	96
14 hours	100	...	100	
15 hours				
20 hours				

C O Present After Adding Lime Water.

	.00305%	.00595%	.01136%	.02083%	.02885%	.04167%
½ hour	77	95	98	100	100	95
3 hours	91	100	100	100	100	98
14 hours						
15 hours	100	98	100	100	96	
20 hours						

Complainants' Exhibit—Extract from Richards' Ore Dressing.

~~14 hours~~				....	....	....
15 hours				~~100~~	~~96~~	....
20 hours				....	....	....

Time of Settling	Hydrochloric Acid. 0.19%	0.39%	0.77%	Sulphuric Acid. 0.15%	0.29%	0.57%
½ hour	100	100	100	100	96	99
14 hours	100	......	......	99	....	....

Varying proportions of salt and of alum were added in fine powder and stirred in. Where lime (CaO) was used, it was added as clear (filtered) lime water, in order to eliminate any possible mechanical effect of suspended lime. The lime water contained 0.125% CaO; and the per cents., of CaO indicated in the table show the amount present after adding respectively 25, 50, 100, 200, 300 and 500 cc. of lime water to 1,000 cc. of the slime. The tests in which lime was used were also stirred, to produce a thorough mixture. In this connection, it should be noted that while the simple addition of even the smallest quantities of lime used caused the slime to agglomerate into distinct grains*, a fairly vigorous stirring caused it to form into comparatively large flakes which settled much more rapidly than the grains. Violent stirring, however, tended to break up these flakes and so hinder the settling somewhat. The stirring seemed also to help teh coagulation in the case of salt and alum, but it did not produce large flakes.

*Before adding anything to the slime the suspended matter was too fine for the eye to distinguish individual.

Complainants' Exhibit Assignment Froment to Ballot, November 17, 1903.

No. 12788/1902.

THIS INDENTURE made the seventeenth day of November One thousand nine hundred and three BETWEEN ALCIDE FROMENT of Traversella in the Kingdom of Italy Engineer (hereinafter called the Vendor) of the one part and JOHN BALLOT of Salisbury House, Finsbury Circus in the City of London Esquire (hereinafter called the purchaser) of the other part WHEREAS His Gracious Majesty King Edward VII by Letters Patent under the Seal of the Patent Office, bearing date the Fourth day of June One thousand nine hundred and two and numbered 12778 did for himself, his heirs and successors give and grant unto HENRY HARRIS LAKE of 45 Southampton Buildings in the County of Middlesex Patent Agent his executors, administrators and assigns, especial license, full power, sole privilege and authority to make, use, exercise and vend an Invention of "Improvements relating to the Concentration of Ores" within the United Kingdom of Great Britain and Ireland and Isle of Man, during the term of Fourteen Years from the day of the date of said Letters Patent, subject to the conditions in said Letters Patent contained. AND WHEREAS the said Letters Patent were granted to the said Henry Harris Lake on behalf of the Vendor as a communication from abroad. AND WHEREAS by an Indenture dated the 13th day of November 1903 and made between the said Henry Harris Lake of the one part and the Vendor of the other part the said Letters Patent and the full benefit thereof were duly assigned to the vendor as in the said Indenture men-

Complainants' Exhibit—Assignment Froment to Ballot, November 17, 1903.

tioned. AND WHEREAS the Vendor has agreed with the purchaser to assign unto him all his right title and interest in and to the said invention in the manner hereinafter contained. NOW THIS INDENTURE WITNESSETH that in pursuance of said agreement, and in consideration of the sum of Two hundred and twenty five pounds sterling on or before the execution of these presents to the Vendor paid by the Purchaser (the receipt whereof is hereby acknowledged) he the Vendor DOTH hereby as beneficial owner assign and convey unto the Purchaser his executors, administrators and assigns ALL THOSE the said invention Letters Patent and premises hereinbefore mentioned, with all profit, benefit, commodity and advantage therefrom arising TO HOLD the same during all the residue of the term of said Letters Patent, or any prolongation of the said term, unto the Purchaser his executors, administrators and assigns, for his and their sole use and benefit. Together with all improvements in the said invention which the Vendor may either by himself or in conjunction with any other person or persons invent or discover and the right for the Purchaser his executors, administrators and assigns to take out patents or other protection for the said invention or for any such improvements as aforesaid in any country colony or place except in the Kingdom of Italy that the Purchaser his executors, administrators or assigns may deem requisite or advisable. And the Vendor hereby covenants with the Purchaser that he the Vendor will forthwith forward or hand to the Purchaser the plans and diagrams of the plant re-

Complainants' Exhibit—Assignment Froment to Ballot, November 17, 1903.

lating to the said invention with a full description of the working of the process and that he the Vendor will from time to time forthwith communicate to the Purchaser his executors, administrators or assigns each and all such improvement or improvements as aforesaid and will in like manner forward or hand to the Purchaser his executors, administrators or assigns the plans and diagrams of the plant relating to such improvement or improvements with full descriptions of the working of the same and that he will give to the Purchaser his executors, administrators and assigns the benefit of his advice in relation to the said invention and to any such improvement or improvements as aforesaid as and when the same may be required. AND FURTHER that he the Vendor will from time to time and at all times hereafter make such declarations and execute and sign such deeds and documents and do such other acts and things as may be required by the Purchaser his executors, administrators or assigns for obtaining such further Patents or other protection as aforesaid and for vesting the same and the full benefit thereof in the purchaser his executors, administrators and assigns AND the Vendor hereby covenants with the purchaser that notwithstanding anything by the Vendor done executed or omitted or knowingly suffered the said Letters Patent au ~~are valid and~~ subsisting ~~and in no wise void or voidable~~.

IN WITNESS WHEREOF the said parties have hereunto set their hands and seals the day and year first above written.

Nine words are struck out.
A. F.
J. B.
F. C.

A. FROMENT. (Seal)

Complainants' Exhibit—Assignment Froment to Ballot, November 17, 1903.

SIGNED, SEALED and DELIVERED
by the said ALCIDE FROMENT, in the
the presence of

G. B. Zanardo, 9, Via Due Macelli, Rome.

Before me,
F. COSSIRINI.
British Proconsul.
JOHN BALLOT. (Seal)

SIGNED, SEALED and DELIVERED
by the said JOHN BALLOT, in the
presence of

G. B. Zanardo, 9 Via Due Marcelli, Rome.

Before me.
F. COSSIRINI,
British Proconsul.

Complainants' Exhibit Froment Italian Patent.

Provi. de Rome.

Regro Genle Vole 43, No. 63723.
Regro Attes. Vol. 156, No. 166.

Description de l'invention ayant pour titre:

Procédé pour l'enrichissement des minerais sulfurés cuivreux, plombeux, blendeux, etc. par les gaz combinés aux corps gras

par:—

Mr. Ing. Alcide Froment, a Traversella (Italie).

Les phénomènes suivants étudiés par l'inventeur, ont servi de base au procédé dont il est cas:

1. Lorsque les sulfures naturel réduits en poudre fine sont mouilles par un corps gras, ils ont une tendence à se réunir en sphérules et à venir flotter à la surface de l'eau.

2. Cette tendance est simplement retardée par le poids spécifique et contrariée par la gangue qui imprisonne les sulfures mouillés dans sa masse pulvérulente.

3. Si un gaz quelconque se degage dans cette masse, les bulles de ce gaz se recouvrent d'une enveloppe de sulfures lesquels s'élèvent facilement ainsi au dessus du liquide pour y venir former une espèce de magma métallique.

4. La formation de ces sphérules métallique est singulièrement activée si le gaz est à l'état naissant.

Ainsi par exemple, si dans un tube à éssais nous mettons une dizaine de grammes de minerai de cuivre sulfuré avec sa gangue, un gramme de calcaire, le tout réduit en poudre, si nous y ajoutons 30 grammes d'eau, quelques jouttes d'acide sulfurique et une mince couche d'huile ordinaire, si nous agitons pendant une seconde, nous verrons toute la chalcopyrite monter instantanément au

dessus du liquide et serrées les unes contre les autres, les sphérules métalliques viendront se grouper en magma nettement séparé du reste du liquide. Si le calcaire est en excés on de facile attaque, la rapidité de la séparation est tellement instantanée que la chalcopyrite est projetée avec force hors du récipient. Il y a donc une mesure a chercher pour un minerai es un calcaire donnés

Le peu de gangue entrainée mécaniquement retombe peu à peu et les sulfures restent à l'état de pureté presque complète. Cel est le principe.

Donc, la rapidité de la formation des sphérules et de leur ascension est en raison directe de la quantité de gaz produit en un même temps.

Exemple 1. Un minerai cuivreux contenant 12% de chalcopyrite 15% de pyrite de fer, 20% de carbonate de fer, 16% de dolomie et de calcite et 37% de gangues diverses, à été soumis au procédé dont il est cas. Il est à noter que ce minerai n'avait pu être enrichi économiquement par aucun moyen connu.

Il a suffi de quelques secondes seulement pour que le sulfure de cuivre soit complètement séparé du reste de la gangue dons laquelle l'analyse n' a pu décéler aucune trace de cuivre.

Exemple 2. Un minerai calciteux à 10% de plomb, invendable avec cette teneur, à été ainsi traité avec le même succès. Il y a plurieurs opérations distinctes mais liées dans la pratique du procédé: formation des sphérules et leur séparation de la gangue. Puis, separation du concentré d'avec l'huile et récupération de cette derniere qui ventre dans le circuit. Les concentrés se trouvent sous forme de tourteaux

Revendication.

Je revendique donc comme ma propriété exclusive et entière un procédé qui consiste à enrichir les minerais sulfures ou autres, minerais graphiteux et dérivés, terres

Complainants' Exhibit—Translation of Froment Italian Patent.

sulfureuses ou autres à l'aide des gaz quels qu' ils soient combinés avec un corps gras oléifiant (et non avec un corps huileux dérivé des bitumes, goudron, naphte, etc.) et quelque soit l'appareil sane lequel ce procédé puisse être appliqué.

Roma, 20 Maggio, 1902.
p.p. Ing. Alcide Froment,
G. B. Zanardo

Il Segratario
E. Livoni
Il Direttore Capo della Division I
F. Lanusol.

Complainants' Exhibit Translation of Froment Italian Patent.

Reg*ro* Genle Vole 43 No. 63,723
Reg*ro* Attes, Vole 156 No. 166.

Description of the Invention having for Title

A Process for Enriching Sulphide and Copper Ores, Lead Ore and Blende by Gases combined with Fatty Bodies.

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by

Mr. Ing. ALCIDE FROMENT, of Traversella, Italy.

The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

Complainants' Exhibit—Translation of Froment Italian Patent.

1. When the natural sulphides reduced to fine powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of water.

2. This tendency is simply retarted by the specific weight, and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

3. If a gas of any kind is generated in this mass, the bubbles of this gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

4. The formation of these metallic spherules is singularly active if the gas is in a nascent state.

Thus for example, if in a test tube there is placed ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the whole reduced to powder, and if there is added thereto 30 grammes of water, a few drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a second, the whole of the copperpyrite will instantly rise to the top of the liquid. The metallic spherules pressed one against the other, will become grouped in a magma clearly separated from the remainder of the liquid. If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the copperpyrite is forcibly ejected from the vessel. Therefore, a correct proportion has to be found for a given ore and a given limestone.

The small quantity of gangue mechanically entrap-

Complainants' Exhibit—Translation of Froment Italian Patent.

ped gradually falls and the sulphides remain in a state of almost complete purity. Such is the principle.

Accordingly, the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

EXAMPLE 1.

A cuprous ore containing 12% of copperpyrite, 15% of iron pyrite, 20% of carbonate of iron, 16% of Dolomite and Calcite and 37% of various gangues have been submitted to said process. It should be stated that this could not have been enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis.

EXAMPLE 2.

A calcitous ore having 10% of lead and unmarketable with such a proportion, has been treated in the same manner and with the same success. There are several distinct but connected operations in the practical working of the process; the formation of the spherules and their separation from the gangue, then separation of the concentrate and the oil and recovery of this latter for re-entrance into the circuit of operations. The products of the concentration form oil cakes.

Complainants' Exhibit—Translation of Froment Italian Patent.

CLAIM.

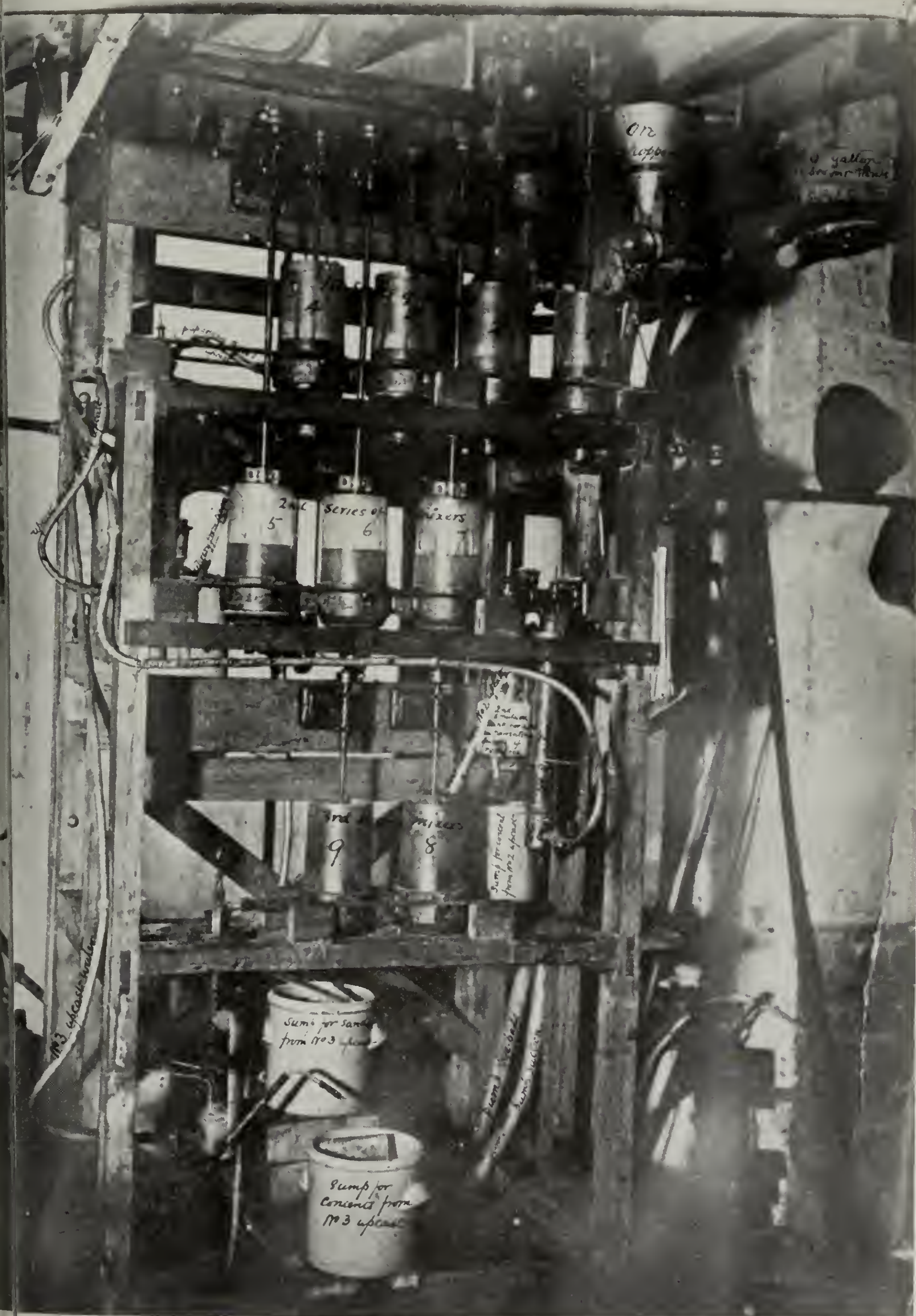
I therefore claim as being my exclusive and entire property a process consisting in enriching sulphide and other ores, graphiteous ores and their derivatives, sulphide earths or others, by means of gases whichever they may be, combined with an oily fat body (and not with an oily body derived from bitumens, tar, naptha, etc.,) and whatever may be the apparatus in which this process could be applied.

Rome, May 20, 1902.

ALCIDE FROMENT,
By G. B. Zanardo, Attorney.
By The Secretary,

E. Livoni,
The Head Director of the First Division,
F. Lanuso.

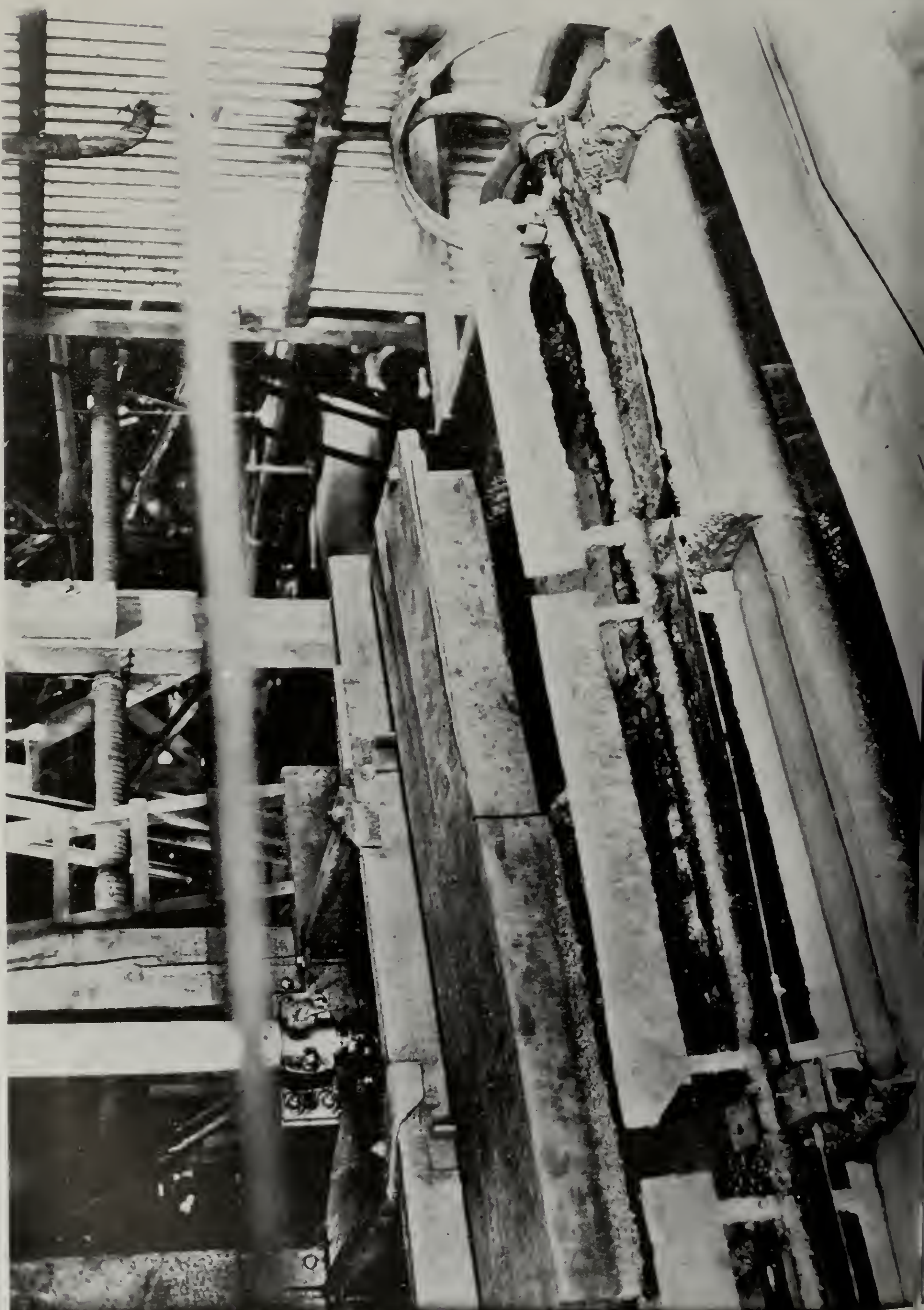
COMPLAINANTS' EXHIBIT
PHOTOGRAPH AUSTRALIAN CATTERMOLE PLANT



COMPLAINANTS' EXHIBIT
SULPHIDE CORPORATION RETREATMENT PLANT
PHOTOGRAPH 1.


COMPLAINANTS' EXHIBIT
CORPORATION RETREATMENT PLANT
PHOTOGRAPH 2.

COMPLAINANTS' EXHIBIT
SULPHIDE CORPORATION RETREATMENT PLANT
PHOTOGRAPH 3.



COMPLAINANTS' EXHIBIT
SULPHIDE CORPORATION RETREATMENT PLANT.
PHOTOGRAPH 4.

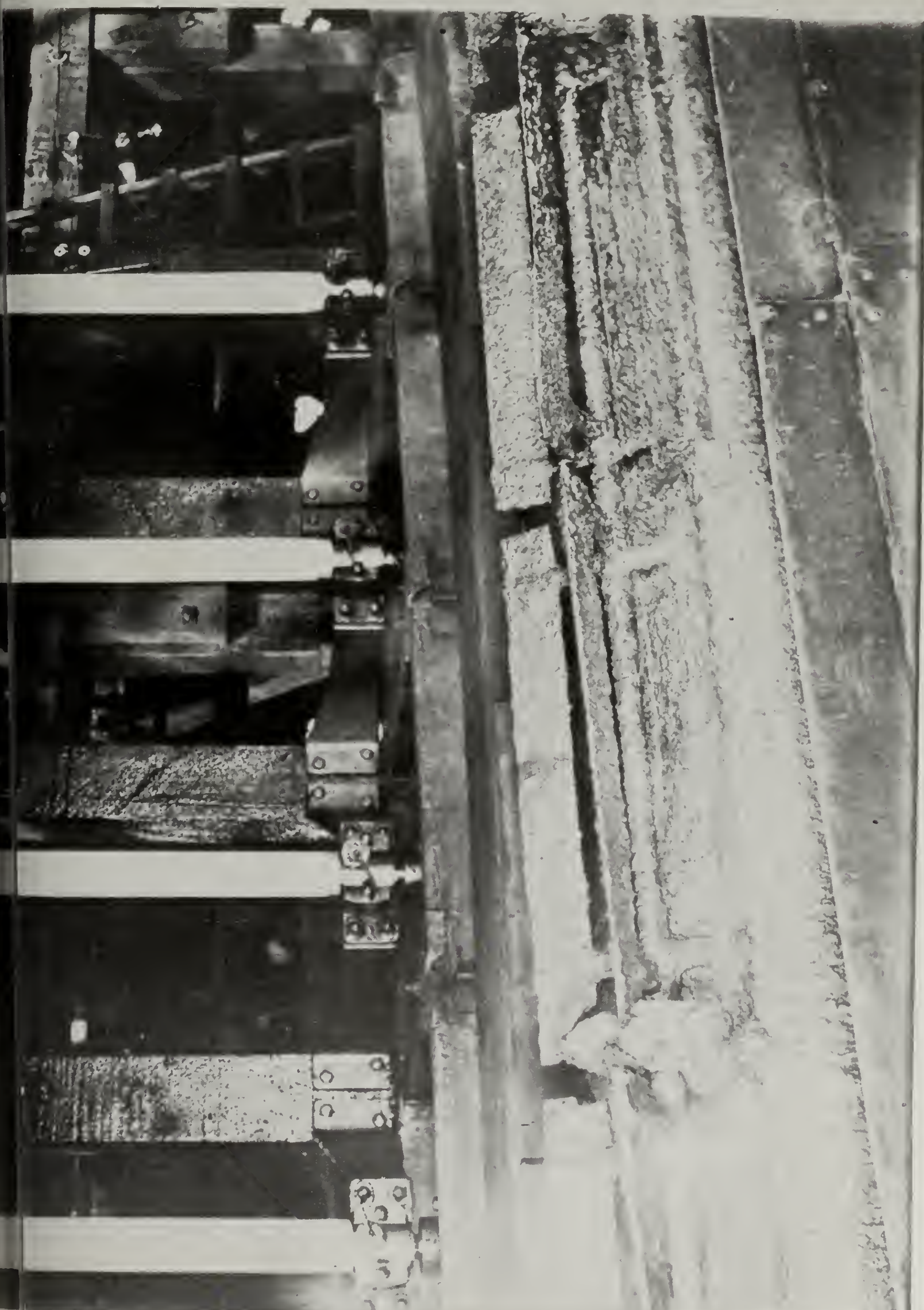


TABLE OF MATERIAL TREATED AND TONNAGE OF ZINC LEAD SILVER CONCENTRATES OBTAINED BY SULPHIDE CORPORATION LD. WITH MINERALS SEPARATION AGITATION FROTH PROCESS _.

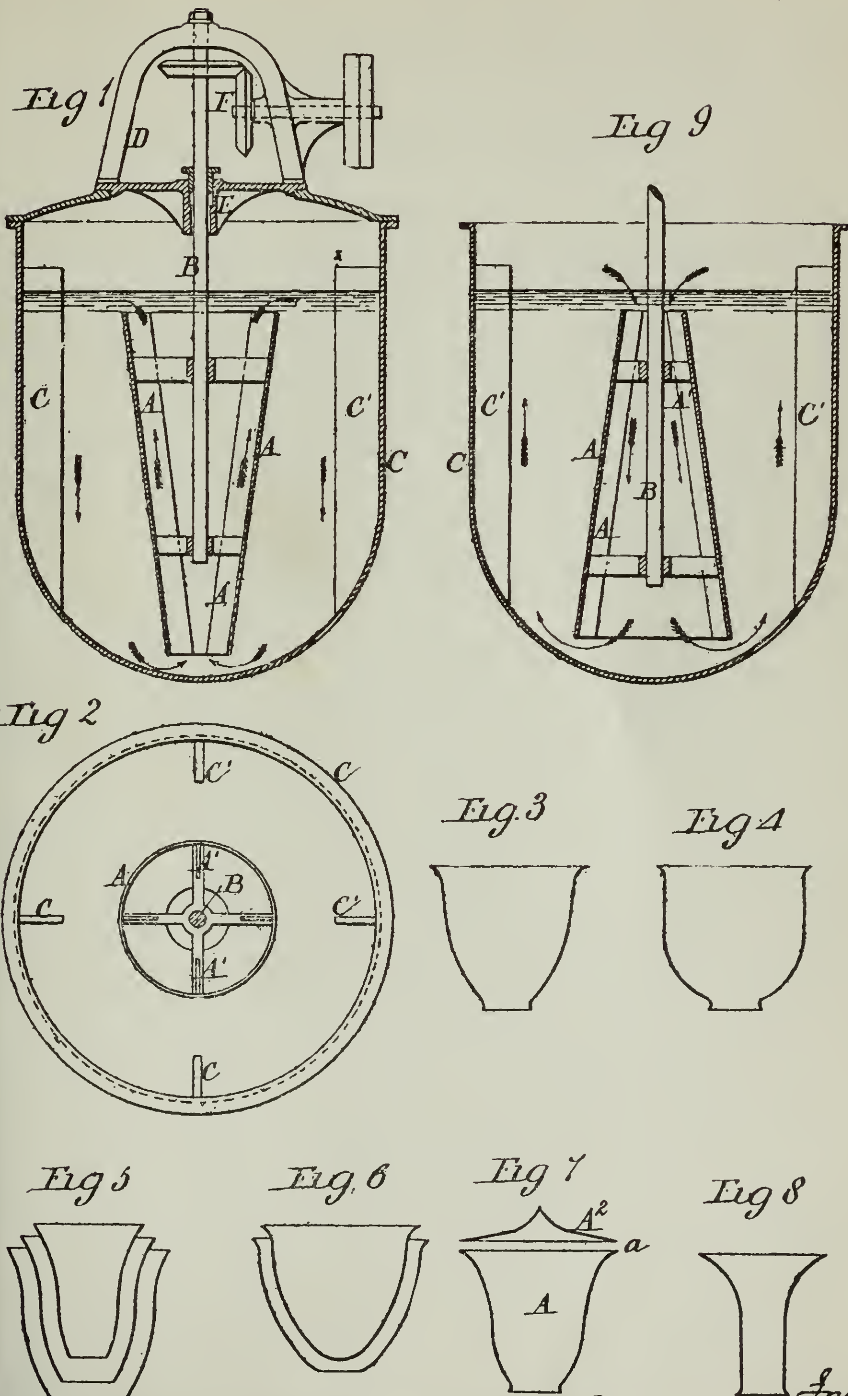
Period	Material	Feed Tonnage		Concentrates Produced Tons		Total Value £	£
						{Calculated on average Price of Spelter for year}	
Old Tailings Plant							
year ending 30 June 1906	Tailings	23,709		8013		28174	
30 June 1907	do	65,705		20,621		75378	
30 June 1908	do	46,394	135,808	16513	45,147	40240	143792
Minerals Separation Ltd Tailings Plant							
year ending 30 June 1908	Tailings	34,506		12,529		31,988	
" 30 June 1909	do	40684	75,190	14464	26,993	34994	66,982
New Mill Zinc Section							
year ending 30 June 1907	By products from Pb section	28,275		6,894		12,517	
30 June 1908	do	157,142		54,842		106,799	
30 June 1909	do	157907		67,981		138,518	
30 June 1910	By products from Pb section Tailings from annex	179,997 47,129		88,767		218598	
30 June 1911	By products from Pb section Tailings from annex	183,322 2,748		71,664		177,447	
30 June 1912	By products from Pb section Dump Slimes Old Tailings	180,308 3,665 487		69,826		263,034	
			940980		359,974		917213
	Total		1,151,978		432,114		£ 1,127987
Joint Slimes Plant							
year ending 30 June 1908	Slimes	4382		(ZnPb) 1,738 (Zn) 131 (Pb) 43			
30 June 1909	do	2179		(ZnPb) 1,109			
30 June 1910	do	18395	24956	(ZnPb) 10,164	13,185		26,366
	Total		1,176934		445299		£ 1,154353

Complainants' Exhibit-Table of Sulphide Corporation Operations with Agitation Froth Process

(No Model.)

E. R. GABBETT
APPARATUS FOR MIXING LIQUIDS.

No. 444,345 — Patented Jan 6, 1891.



Witnesses
A. Rutherford
Geo. [illegible]

Inventor
Edmond R. Gabbett
By James L. Norris.
Atty.

EDMOND R. GABBETT, OF OLD CHARLTON, ASSIGNOR OF ONE-HALF TO SAMUEL BAGSTER BOULTON, THOMAS BURT HAYWOOD, AND HAROLD EDWIN BOULTON, ALL OF LONDON, ENGLAND

APPARATUS FOR MIXING LIQUIDS

SPECIFICATION forming part of Letters Patent No. 444,345, dated January 6, 1891.

Application filed July 23, 1890. Serial No. 359 670. (No model.) Patented in England January 16, 1889, No. 840 in Belgium August 17, 1889, No. 87,411, and in France August 12, 1889, No. 200,153

To all whom it may concern.

Be it known that I, EDMOND RICH GABBETT, a citizen of England, residing at Old Charlton, in the county of Kent, England, have invented new and useful Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi-Liquids in Vessels, (for which patents have been obtained in Great Britain dated January 16, 1889, No. 840; in Belgium dated August 17, 1899, No. 87,411, and in France dated August 12, 1889, No. 200,153,) of which the following is a specification.

According to this invention I effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a caldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing or circulation of the liquid entirely by centrifugal action, I avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling-blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to my invention. Thus, according to one arrangement I employ a shell of a conical, conoidal, paraboloidal, hemispherical, or trumpet-mouthed shape, fitted, if necessary, with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the caldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well-known manner upon such body of liquid, causing it to rise up on the inner wall of the shell and to flow over the upper edge, then into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

The invention is applied in the manufacture of tar products, in sugar-refining, chemical works, distilleries, soap-works, treating ore for the extraction of gold, and for all purposes where liquids and solids require to be brought into intimate contact, or where a constant circulation of liquids is required.

The invention is illustrated by the accompanying drawings, in which—

Figure 1 shows a vertical section of one form of the above-described apparatus, and Fig. 2 shows a plan. Figs. 3 to 8 show modified forms of the shell. Fig 9 shows an inverted arrangement thereof.

A is a conical shell, having internal ribs A' and mounted on a shaft B, by which it is suspended within the vessel or tank C, containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing-box E on the cover of the vessel C. Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing, such as indicated at F, then the body of liquid within the shell being carried round with the same by means of the ribs A' the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof, while at the same time the pressure of the surrounding column of liquid in the vessel C will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus

a continuous circulation and consequent mixing of the liquid will be effected, as indicated by the arrows.

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A the vessel may be provided with projecting ribs C′, as shown. This is, however, not absolutely necessary, and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular instead of circular, as shown, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving-shaft or arranged in a row; also, instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving-pulleys carrying, respectively, an open and a crossed strap, which are shifted alternately onto a loose pulley, as is well understood. The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A, so that the centrifugal action will cause the liquid within it to travel in a downward direction, as shown at Fig. 9. The shell A may also, if desired, have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts. This might be effected by connecting the lower part of the shaft B, carrying the shell, to the upper part running in fixed bearings by a universal joint and imparting the described motion to and fro thereto by a crank, cam, or eccentric, and connecting-rod or by other suitable means. The shell A may be made to extend above the level of the liquid instead of being entirely immersed, as indicated.

Figs. 3 to 8 show diagram sections of various other forms which may be adopted for the revolving shell. Fig. 3 shows a paraboloidal shape; Fig. 4, a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shows an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action, or there may be only two concentric shells, as at Fig. 6, forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level the arrangement shown at Fig. 7 may be adopted, in which the top of the shell A is covered by a shield A^2, leaving a narrow annular orifice at a for the issue of the liquid. By this means the pressure of the column of liquid which would otherwise exist in the center of the shell is prevented from interfering with the centrifugal action. Fig. 8 shows a construction in which the lower part of the shell is made cylindrical, while the upper part is made trumpet-mouthed, the centrifugal action being in this case confined to the upper part, or the entire shell might be made of a trumpet-mouth shape.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air-tight chamber connected to the shell or shaft. Thus, for instance, the shield A^2, (shown in Fig. 7,) being made hollow, will by its flotation partly carry the weight of the shell, &c., or in that of Fig. 6 if the inner vessel is covered and rendered air-tight the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing, as described, yet it will be evident that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above-described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating-pump within the vessel or caldron would be subject to considerable difficulties.

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

1. An apparatus for mixing or circulating liquids, consisting of a closed tank or vessel for containing the liquid, a rotating conically-shaped shell secured to and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, through the interior of which shell the liquid is caused by centrifugal force to flow in one direction, while the liquid exterior of the shell is caused to flow in a reverse direction, and means for rotating the shell and causing such continuous circulation of the liquid within the tank or vessel and through the shell, substantially as described.

2. An apparatus for mixing or circulating liquids, consisting of a tank or vessel for containing the liquid, a rotating conically-shaped shell having a series of internal ribs immersed and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described.

3. An apparatus for mixing or circulating liquids, consisting of a closed tank or caldron having on its internal surface a series of projecting ribs, the rotating conically-shaped

shell immersed and suspended by a shaft vertically in the liquid, provided on its internal surface with a series of ribs and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 11th day of July, A. D. 1890.

EDMOND R. GABBETT.

Witnesses.

CHAS. D. ABEL,

JNO. P. M. MILLARD.

C. B. HEBRON

PROCESS OF CONCENTRATING ORES.

No. 474,829 Patented May 17, 1892.

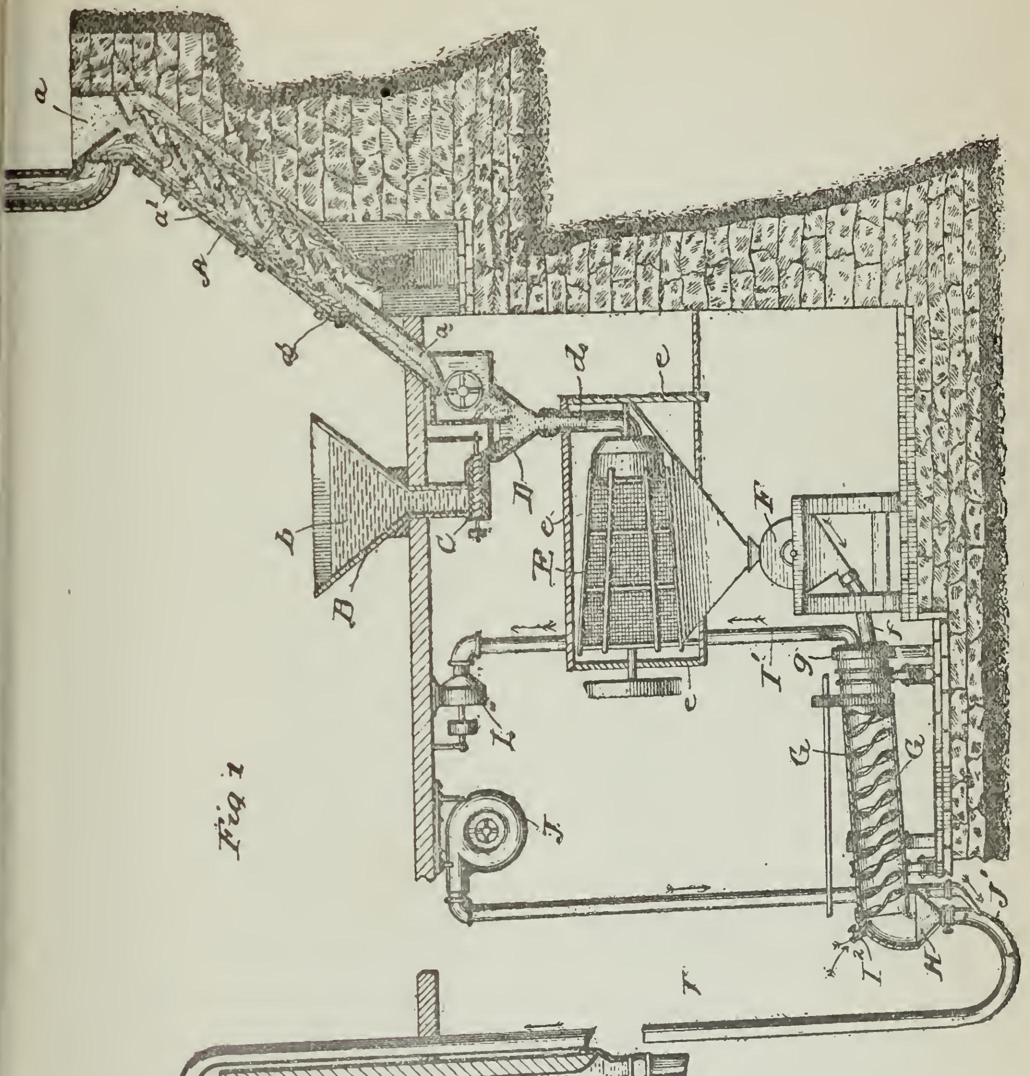


Fig 1

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Inventor;
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(No Model.) 4 Sheets—Sheet 2

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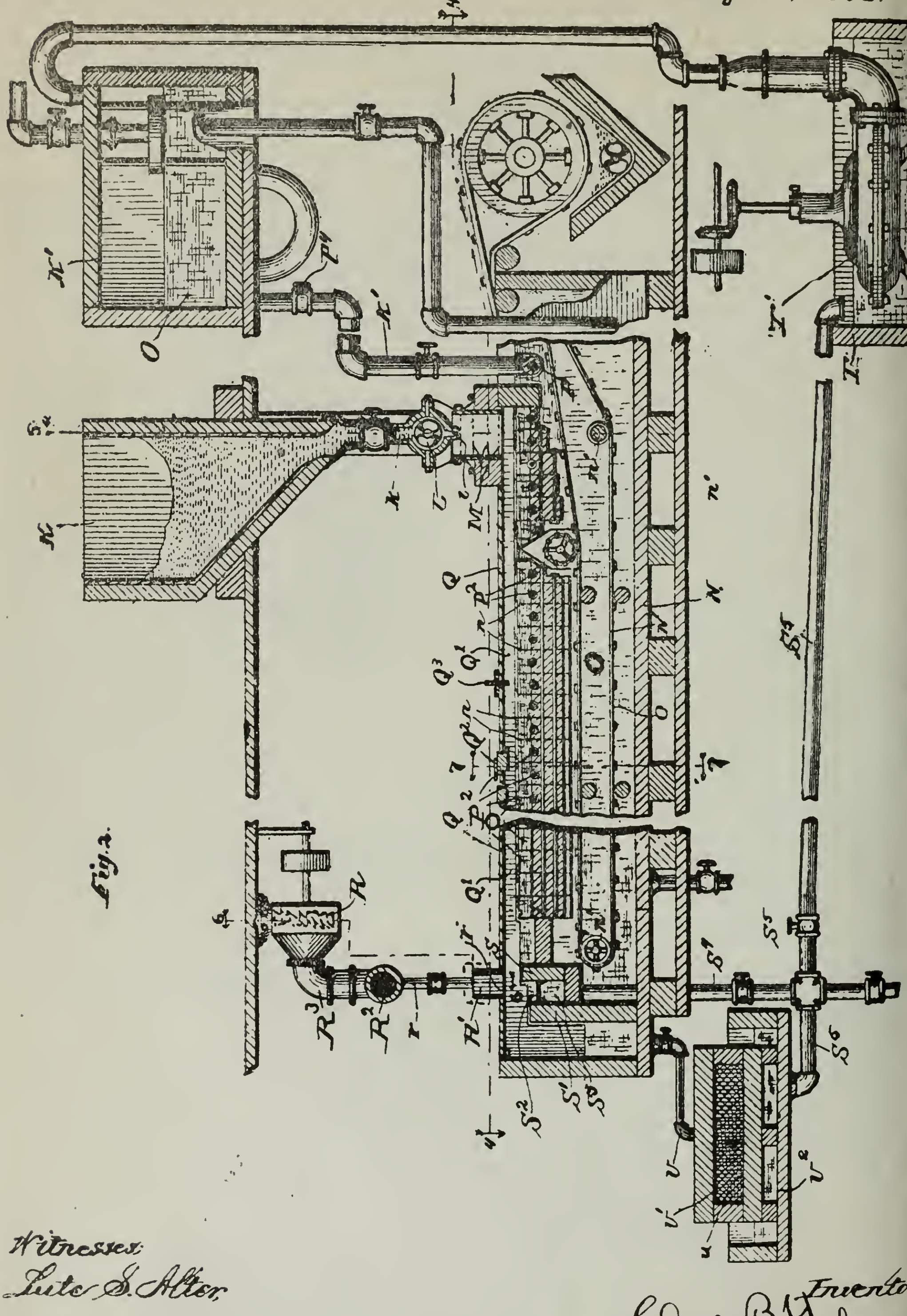

Fig. 2.

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C. B. HEBRON
PROCESS OF CONCENTRATING ORES.

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Fig. 3.

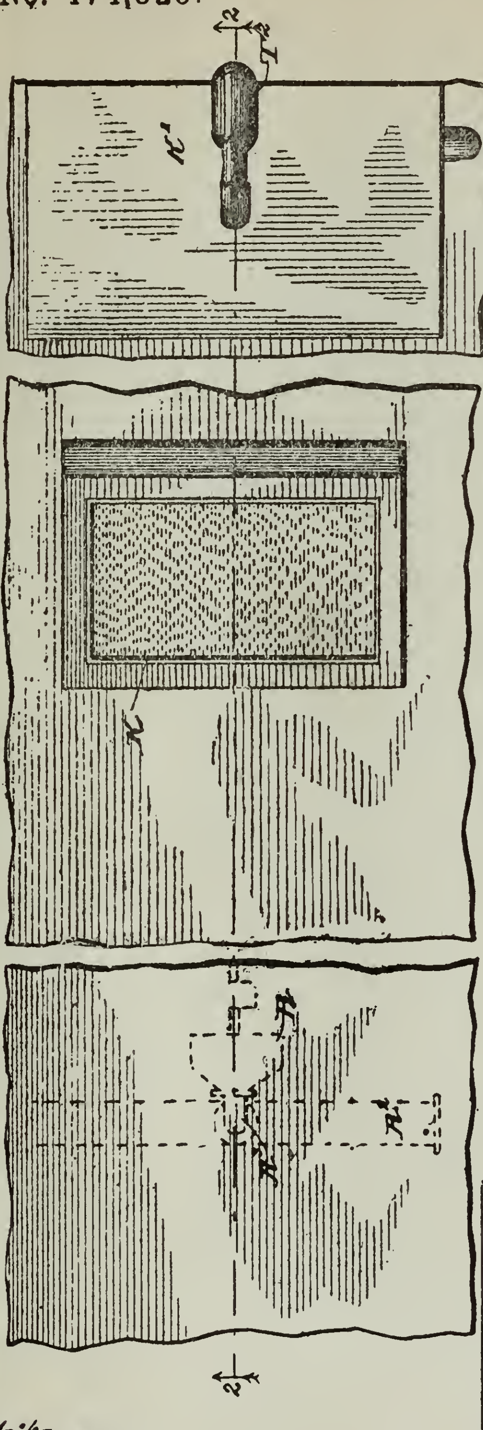
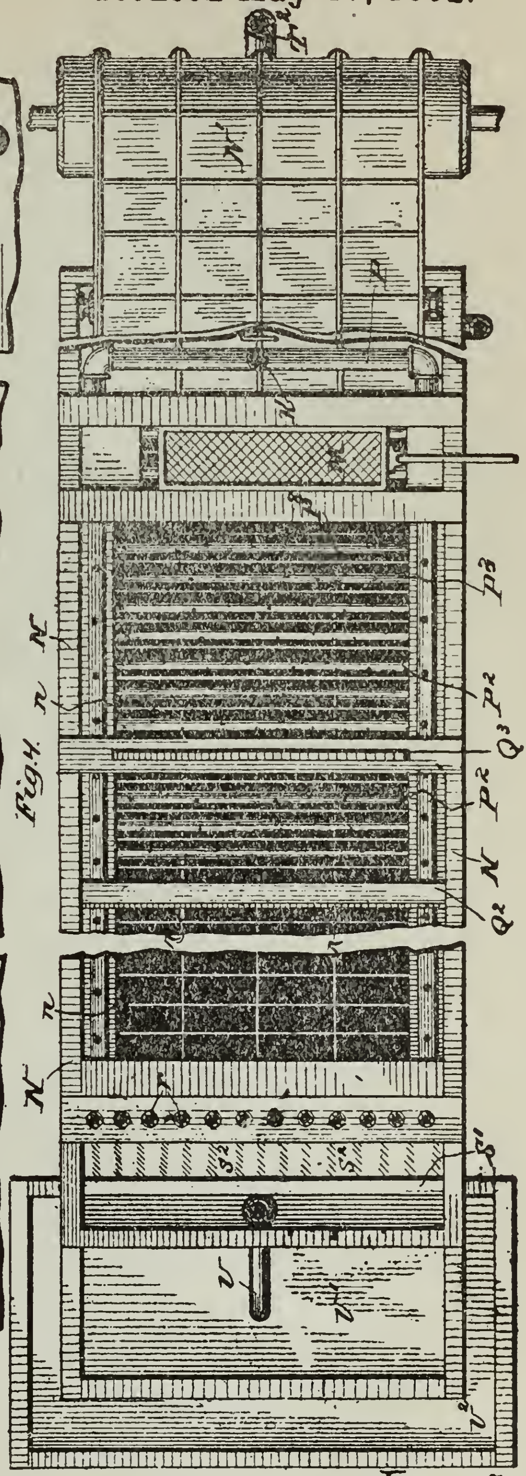


Fig. 4.



Witnesses

Lute S Alter

Inventor;

Charles B Hebron,

By

(No Model.)

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C. B. HEBRON.

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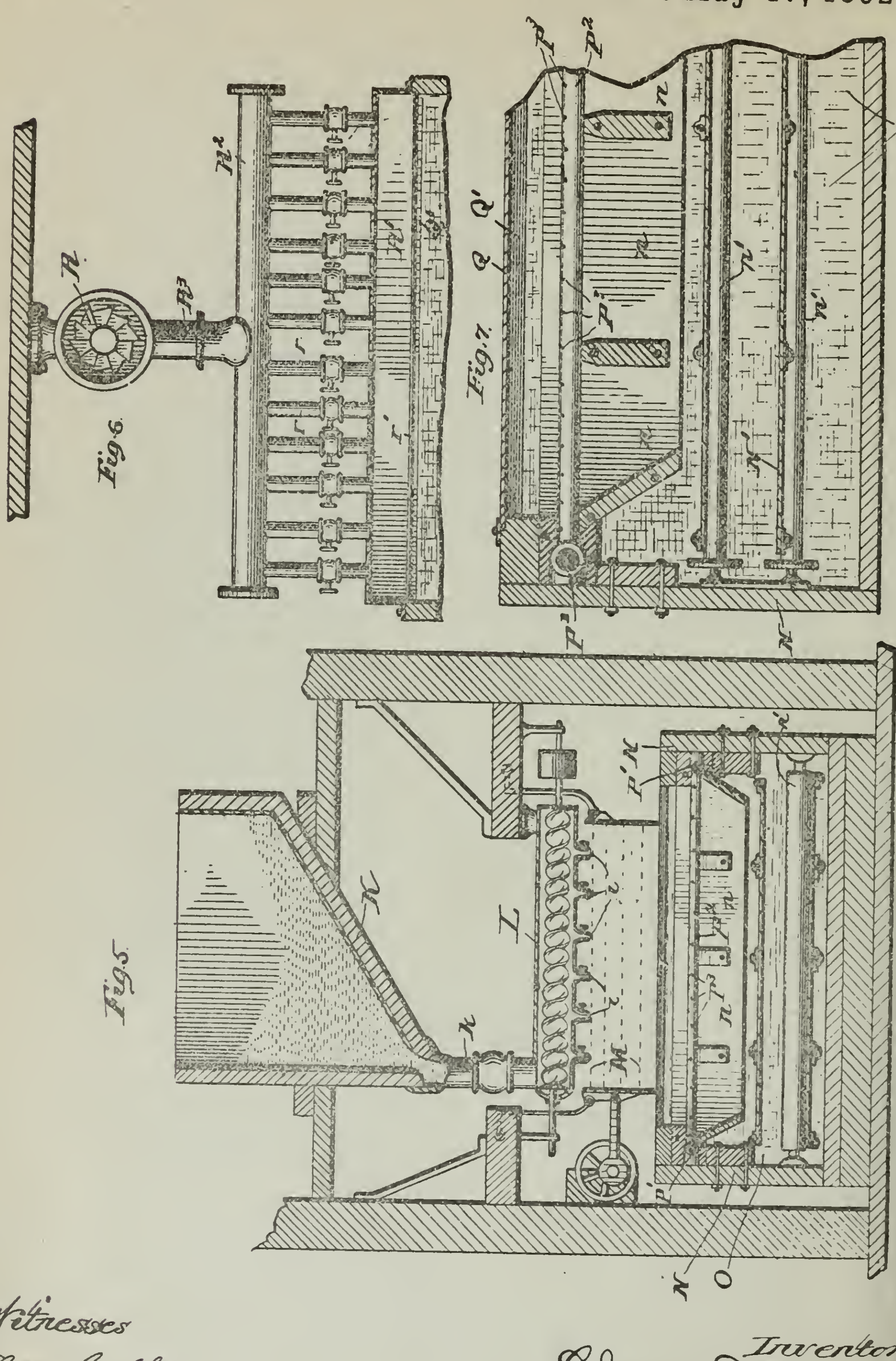

Witnesses
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Flora L. Brown

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By Charles T. Br...

UNITED STATES PATENT OFFICE.

CHARLES B. HEBRON, OF DENVER, COLORADO, ASSIGNOR OF FIVE-SEVENTHS TO CARRIE J. EVERSON, OF SAME PLACE, MAMIE W. HUTCHINSON, OF TOPEKA, KANSAS, AND CHARLES T. BROWN, OF CHICAGO, ILLINOIS.

PROCESS OF CONCENTRATING ORES.

SPECIFICATION forming part of Letters Patent No. 474,829, dated May 17, 1892.

Application filed July 22, 1891. Serial No. 400,354. (No model.)

To all whom it may concern:

Be it known that I, CHARLES B. HEBRON, a citizen of the United States, residing at Denver, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Processes for the Concentration of Ores; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to practice the same.

My invention relates to a process for the separation or concentration of certain kinds of ores heretofore found particularly intractable and practically impossible to separate; and it consists of certain doings constituting an improvement on the process heretofore invented by Carrie J. Everson and myself jointly, such joint invention being described and claimed in the application for a patent filed by us on the 1st day of September, 1891, Serial No. 404,400, allowed January 9, 1892, and may be considered as founded upon the same principles as is the process described in the application referred to, in conjunction with other principles not therein set forth. The process described in such joint application consists, briefly stated, in first pulverizing the ore to the proper fineness, (which pulverization must in every instance reach the cleavage or disintegration of the ore and may be much finer than that required to reach such cleavage or disintegration in cases where the mineral particles of the ore are in coarse dissemination in the rock, or where free metal is mechanically combined with rock,) after such pulverization applying to the ore while in a dry state a quantity of dry buoyant material, with proper pressure and movement, as by rubbing under pressure—say with the use of burrs or equivalent mechanical devices—whereby the buoy stock is forced into the openings or interstices existing between the atoms constituting the porous metallic and mineral particles, or is caused to adhere to the irregular or roughened surface of such metallic and mineral particles and said particles thereby made buoyant, and the ore stock thus prepared being subsequently delivered to or upon the surface of the water in suitable manner to subject the same to flotation thereupon, the buoyant mineral and metal particles remaining as a scum upon the water, while the rock matrix of the ore stock, or, in mining parlance, the "gangue" thereof, settles, resulting in separation.

It is to be understood that the foregoing briefly-described process and the herein described and claimed process are based upon the difference in formation between the rock crystals and the mineral and metal particles constituting the ore adapted for treatment by this process, the latter being porous, while the former are crystalline in character and the surface thereof glassy, whereby the buoy stock may be said to attack the disintegrated metallic and mineral particles without affecting the smooth rock crystals, such difference in structure between the mineral and metal particles and the rock crystals being distinctly marked in the class of ores I seek to separate by this process.

My present invention or discovery relates to the preparation of the ore for the presentation thereto of the buoy stock in such manner and by such means that the mineral and metal particles contained in such ore stock are made to receive greater quantities of such buoy stock than has been heretofore possible.

In properly-pulverized ore of the class or kind which this invention relates to the mineral and metal particles, being of the character hereinbefore described, when at about climatic temperature contain and are surrounded by particles of air or other gases, and the presence of such air or other gases retards, hinders, and partially prevents the attachment to and joining with such particles of as large a bulk of buoy stock as is possible when such air or other gases are not present Further, if the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles in the ore are enlarged, (particularly when such enlargement is obtained in connection with the absence of air or other gases in or on such particles,) and at such time the buoy stock is presented thereto and thoroughly pressed therein, the capacity of such particles for containing and mechanically joining with the buoy-stock material is increased.

The object of my invention is to obtain greater buoyancy in the joined mineral and

metal particles and buoy stock than has heretofore been obtained, and to attain such object I expel from such mineral and metal particles an appreciable quantity of the air and other gases contained in the openings, cells, cavities, depressions, or pores thereof, or surrounding them at the time of presenting thereto and pressing thereinto the buoy stock by producing as far as practicable a vacuum in the receptacle containing the ore and the buoy stock and the mechanism effecting the joining of the mineral and metal particles of the ore with the particles of the buoy stock, or, and preferably, by applying heat to the ore, thereby obtaining the desired expulsion of air and other gases prior to the presentation to and pressing of such buoy stock into and upon the mineral and metal particles of the ore, and retaining such heated condition in the ore until such buoy stock is properly brought in contact with the mineral and metal particles thereof and pressed therein and upon, thus producing at the same time an enlargement of the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles.

In order to heat the previously-pulverized ore, it is placed in a receptacle, where it is subjected to a dry artificial heat of considerable intensity, but not sufficient to materially volatilize the values thereof.

I have found the following-described mechanical devices used in the herein-stated manner efficient in reducing my invention to practice, to wit: an infusion fire-blast rotary cylindrical furnace, or the equivalent thereof, into which the ore stock is continuously fed at one end and conveyed through the fire-chamber thereof to and discharged at the other end onto a shaking or rotating screen, which is closely housed for the purpose of checking radiation of heat, an automatic conveyer by which the buoy stock is fed in a cold and preferably chilled condition from its storage-receptacle to the same screen on which the heated ore is being fed, whereby the buoy stock and the pulverized ore passing through the meshes of the rapidly-oscillating screens are commingled prior to their delivery therefrom; suitably - adjusted rotary burr-disks between which the ore and buoy stock are delivered from the screen, whereby the buoy stock particles are pressed into and upon the heated mineral and metal particles of the ore; a cooling and aerating device by which the ore stock thus far prepared is cooled and aerated, and an ore-separator.

The amount of buoy stock supplied to the ore is determined by the bulk of metal and mineral contained in the ore. The buoy stock should, I find, be approximately equivalent in bulk to the bulk of such mineral, the ore having prior to the delivery thereof to the oscillating or rotary screen where it is first brought in contact with the buoy stock been heated in the furnace to considerable intensity and in excess of the temperature required to properly expel the air and other gases therefrom and obtain the maximum enlargement of the openings, cells, cavities, depressions, or pores thereof. Provision is thereby made for the partial cooling of the ore, which results from contact with the mineral and metal particles thereof, and pressing thereinto and thereon of the cold or chilled buoy stock particles and from radiation, and such excess must be sufficient to maintain in the ore stock while between the burr-disks the heated condition necessary for preserving the practical expulsion of the air and other gases from the mineral and metal particles, so that the partial vacuumed condition attained in the openings, cells, cavities, depressions, or pores of the mineral and metallic particles shall not be broken until the buoy stock particles have been joined thereto. To aerate such joined metallic and mineral and buoy-stock particles a blast or current of cold and preferably chilled air is blown through the so-far-prepared ore stock as it falls from the slots in the hopper, into which it is delivered from the burrs, or as it passes through a conveyer before reaching such hopper. This blast of cold or chilled air, in addition to aerating and cooling the nearly-prepared ore stock, can be of sufficient volume and force to convey the ore stock to a receptacle, from which it is taken by an automatic conveyer in proper quantities to supply the working capacity of the separator.

A suitable separator for use in this process consists of a rectangular tank placed in a horizontal position and nearly filled with liquid, the width of which tank is determined by the capacity desired, the depth being sufficient to have contained under the surface of the liquid therein partitions provided for stalling the current of the liquid in the tank below the surface thereof, and for an endless apron-belt movable beneath such partitions with the necessary idlers, pulley-rollers, and supports thereof, on which apron-belt the rock matrix settles, and by the movement of which it is conveyed from the tank to the determined place of deposit therefor. The movement of the apron-belt is toward the head of the tank, and it rises out of the same on an incline at the head, carrying the rock matrix settled thereon out of the tank, and the liquid in the tank is discharged therefrom at the tail thereof, floating the concentrates thereupon. The partitions designed to stall the liquid in the tank extend from one side thereof to the other, and from near the surface of the liquid—that is, from less than one-half inch thereof—to near the endless apron-belt—say within less than one-half inch thereof. The liquid supplied the tank and forming the overflow at the tail thereof is delivered through horizontal pipes extending across the tank between the stalls, the top of such pipes being about one and one-half inches below the top of the stall-partitions, and such pipes being perforated on their upper halves, the liquid which

is contained therein under pressure will, as it is forced through the perforations, produce an effervescing condition at and near the surface of the liquid in the tank, such effervescing condition of the liquid tending to loosen the rock matrix from the buoyed values of the ore stock in the surface-fed charge, causing the rock particles to break away from the same at the surface of the liquid and settle through it between the stall-partitions to the moving endless apron-belt. These perforated pipes, through which the liquid is supplied to the tank, extend from a point underneath the feed-screens for about one-fifth to one-third the length of the separator-tank. For the distance between the tail terminus of this series of pipes and the tail of the series of partitions for stalling the liquid all effervescence ceases, allowing the liquid between such partition-stalls to be calm, thereby offering less obstruction to the settling of the more exhausted rock particles which remain suspended in the shallow current above such stall-partitions for a greater time and distance than the coarser particles of the rock matrix, permitting this more exhausted residuum to settle upon the moving endless apron-belt at points nearer the tail of the separator. The prepared ore stock delivered upon the rapidly-oscillating feed-screens passes through the series of screens and is delivered to the surface of the liquid in the tank in the form of a continuous dust-cloud, and the metallic and mineral values of the ore stock contained therein are separated from the rock matrix, as heretofore described. The longitudinal movement of the floating film or scum containing the values of the ore must be in pace with the supply of ore from the feed, which must be only rapid enough to thinly cover the liquid-surface. A chamber exists between the liquid-surface and the tank-covering, (which should be transparent,) through which a gentle suction air-blast is drawn over the scum longitudinally and exhausted through air-flues rising above the tail end of the separator-tank by means of a suction-fan. This air-blast causes the scum or floating film to move upon the liquid-surface rapidly, thereby increasing the capacity of the separator and admitting of the use of a slow and sluggish surface current above the upper edges of the stall-partitions. This torpid movement of the liquid-current allows the rock particles to settle more easily than if capacity was obtained by a rapid movement of the liquid-surface, which would impart such momentum as to hold the rock particles longer in suspension, and therefore requiring much greater length of tank-surface to obtain a good separation.

The liquid commonly used in the separator-tank is water; but in northern latitudes or in a high altitude, particularly in the winter season, it will be found desirable to use a liquid less subject to freezing than water, and as in this process the product and the residuum of the pulverized ore stock are severally removed from the separator-tank, leaving the liquid employed therein when delivered at the tail end of the apparatus in condition to be returned to the storage and again used, any liquid of sufficient fluidity whereof the specific gravity is less than the specific gravity of the rock matrix can be employed, provided, of course, the separator-tank and its appurtenances coming in contact with the liquid are constructed of material well adapted to resist the action thereof. Hence common brine (a solution of sodium chloride) is practically available, and other liquids might be used.

Between ore specially adapted for treatment by this process and ore unfit to be treated thereby there is found ore wherein the mineral and metallic particles are so dense and compact in physical structure that the buoyant character necessary for the best results in the separator-tank where water is employed as the liquid is somewhat difficult to obtain, even by the use of buoyant particles joined thereto in the manner hereinbefore described, and in such case it will be found highly desirable that brine or some liquid having greater specific gravity than water be employed as a substitute thereof.

In the drawings accompanying and forming a part of this specification mechanisms are illustrated adapted to perform the several functions demanded thereof in the carrying out of this process, and in such drawings—

Figure 1 is a cross-sectional view of a continuous fire-blast furnace and an elevation of the machinery employed therewith, whereby the pulverized ore is properly prepared, as herein described, and deposited in the storage-chamber, such storage-chamber being also shown in cross-section in said figure; Fig. 2, a longitudinal sectional view of an ore-separator on line 2 2 of Fig. 3; Fig. 3, a plan view of a liquid-storage and pipes thereinto and therefrom and a prepared ore-stock storage, forming appurtenances to such ore-separator; Fig. 4, a longitudinal sectional view on line 4 4 of Fig. 2, viewed in the direction indicated by the arrows, the top of the tank of the ore-separator being transparent and so exposing to view the several parts in the tank of the separator; Fig. 5, a vertical cross-section on line 5 5 of Fig. 2, viewed in the direction of the arrows; Fig. 6, a vertical cross-section on line 6 6, also viewed in the direction indicated by the arrows; Fig. 7, a vertical cross-section of a portion of the device, on an enlarged scale, on lines 7 7 of Fig. 2, viewed in the direction indicated by the arrows.

Similar letters of reference are employed to indicate a part where more than one view thereof is shown.

A is a continuous fire-blast furnace, a, the pulverized ore passing through A, and a' the fire-blast of such furnace.

B is a storage-receptacle for the mate-

rial of buoyant character required in this process, which material I prefer shall ordinarily consist of pulverized charcoal.

C is an automatic conveyer, by which the prepared buoy stock is fed from storage-receptacle B to trough D.

E is a rotatory screen, and *e* the housing thereof.

The pulverized and heated ore *a* is delivered from the furnace A, through trough D and pipe *d*, into the rotary screen E, and *b* is the buoyant material contained in storage B, which is also delivered by conveyer C into the trough D, along with the pulverized and heated ore *a*, and passing therewith into the rotary screen E. Rotary burr-disks are contained in the frame F. Such disks being well known in the art, I do not deem it necessary to expose the same to view.

G is a rotary conveyer by which the ore stock delivered thereto from spout *f*, after having passed through the burr-disks, is conveyed to trough H.

I is the fan by which air, preferably cooled or chilled, is drawn through the pipe I′ from cock I^2 in the conveyer G, producing a gentle current over the contents of the conveyer from such cock I^2 to the point in the non-rotatable head *g* thereof, where pipe I′ is secured.

J is a fan by which a current of air can be forced into the pipe J′ and the contents of such pipe be thereby elevated and deposited into the storage-receptacle K, from which they can be delivered to the ore-separator.

The ore-separator which I prefer to use is one wherein liquid is employed as the fluid, through which, by the action of gravity, certain parts of ore stock, as hereinafter explained, will fall and on which other parts of such prepared ore stock will float to the point of delivery therefrom.

K′, Fig. 2, is a storage-receptacle for the liquid required in the separator. From storage-receptacle K a pipe *k*, having a suitable valve therein, extends to the conveyer L, from which conveyer the prepared ore stock is dropped through discharge pipes or nipples *l l* to the shaking-screens M M, through which screens such prepared ore stock passes and from which it is delivered upon the surface of the liquid O, contained in the rectangular tank N. From the storage-receptacle K′ a pipe *k′* extends into the tank N, and through such pipe the liquid O passes into such tank.

n n are the partitions provided in the tank N.

N′ is an endless movable apron-belt beneath such partitions, and *n′ n′* are the idlers or pulley-rollers supporting the belt.

P is a horizontal pipe extending laterally across the tank N below the surface of the liquid contained therein.

P′ P′ are horizontal pipes extending longitudinally for a portion of the length of the tank, and P^2 P^2 are horizontal pipes extending laterally underneath the surface of the liquid in the tank.

P^3 P^3 are holes in the pipes P^2 P^2. The liquid passing from the tank K′ through the pipe *k′* extends through the pipes P P′ P^2 and enters the tank through holes P^3 in pipes P^2. The proper pressure under which the liquid passes out of the holes P^3 P^3 can be determined by valve P^4 in pipe *k′*.

Q is the transparent cover of the tank.

Q′ is the chamber extending between the surface of the liquid and the cover.

R is a suction-fan, and *r r* are pipes extending from chamber R′ to horizontal pipe R^2, such horizontal pipe being connected to fan R by pipe R^3. *r′* is a screen interposed between the chamber R′ and the chamber Q′. The movement of the suction-fan R creates the air-blast hereinbefore referred to in the chamber Q′, between the open slide Q^2 and the chamber R′.

Q^3 is a vertical slide extending from the cover Q through the chamber Q′ to near the surface of the liquid O and prevents any blast or current of air above such liquid between such slide Q^3 and the screens M.

S S′ are bridge-walls over which the liquid and the prepared ore stock thereon passes.

S^2 is a screen or perforated plate between the bridge-walls S S′, through which much of the liquid passing over bridge-wall S can flow into the chamber S^3 underneath the screen, and from thence through pipe S^4 to waste or to pipe S^5, through which it flows to receptacle T, from which, by the pump T′, it can be raised through the pipe T^2 into the receptacle K′. The liquid and prepared ore stock thereon, containing the values of the ore passing over the bridge-wall S′, flow through the pipe U into the receptacle U′.

u u are screens in receptacle U′, through which the liquid can flow into the receptacle U^2, from which receptacle it can flow through pipe S^5 to receptacle T. The prepared ore stock remains in the receptacle U′, from which it is taken when desired.

It will be evident to those skilled in the art that liquid employed as a suspensive fluid in the manner described is not the sole way in which suspension in different strata for sufficient time to separate the buoyed mineral and metallic particles from the rock matrix of the ore can be effected, as any of the well-known stratifying mechanical devices can be used as an element of this process for the purpose of separating the heavier from the lighter particles, and thereby stratifying the ore stock, and when the ore prepared by this process is properly subjected to such mechanical devices it will be found that the buoyed mineral and metallic particles will, being lighter, obtain the upper strata.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The herein-described process for concen

trating ore, consisting of producing a vacuumed condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in such vacuumed condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of aerating such buoyed mineral and metallic particles, and of subjecting such prepared and aerated ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

2. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of subjecting such prepared ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

3. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of presenting such prepared ore stock to the surface of liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock and thereby for such time separated therefrom, substantially as described.

4. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous movement on the surface of a body of liquid by producing an effervescing condition therein below and at the surface thereof, and of presenting such prepared ore stock to the tremulous surface of such liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon such surface for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom, substantially as described.

5. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of presenting such prepared ore stock to the surface of liquid so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and of producing a current of gas moving in relation to the surface of the liquid and in a direction from the place of presentation of the prepared ore stock to the surface thereof, whereby the buoyant mineral and metallic particles of the ore stock are separated from the rock matrix thereof for such time, and particles of the ore stock floating upon the surface of the liquid are moved over and on the surface of such liquid by such current of gas, substantially as described.

6. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous and wavy movement on the surface of a body or liquid contained in a receptacle having stalling-partitions by producing an effervescing condition in the liquid below and at its surface and a current of gas moving over and on such surface, and of presenting such prepared ore stock to the surface of the liquid, so that the buoyed mineral and metallic particles of ore are maintained on the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom and the particles of ore stock floating on the surface of the liquid moved on and over such surface, substantially as described.

CHARLES B. HEBRON.

Witnesses:

WILLIAM B. ELLIS,
CHARLES T. BROWN.

(No Model.)

2 Sheets—Sheet 1

G. ROBSON

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669. Patented Jan. 19, 1897.

Fig. 1.

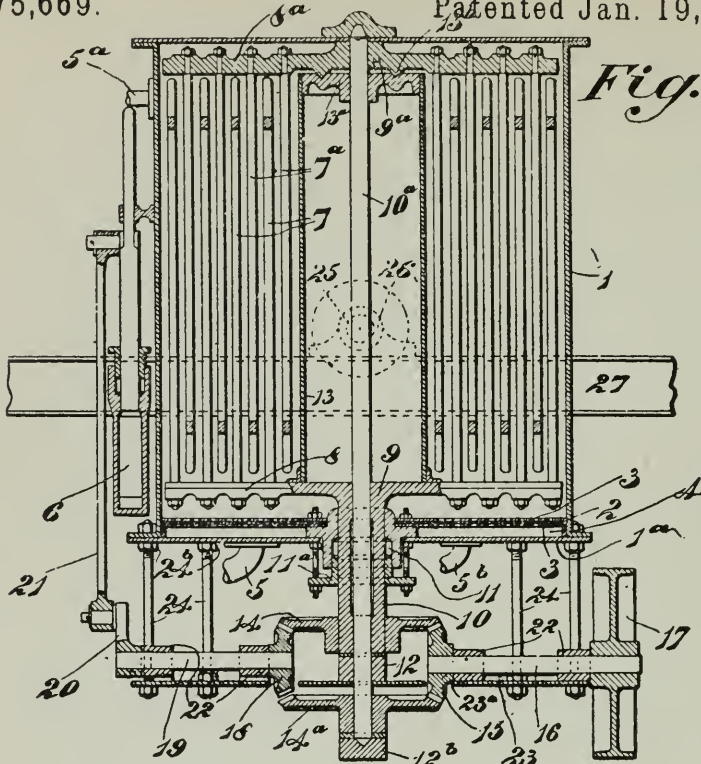


Fig. 2.

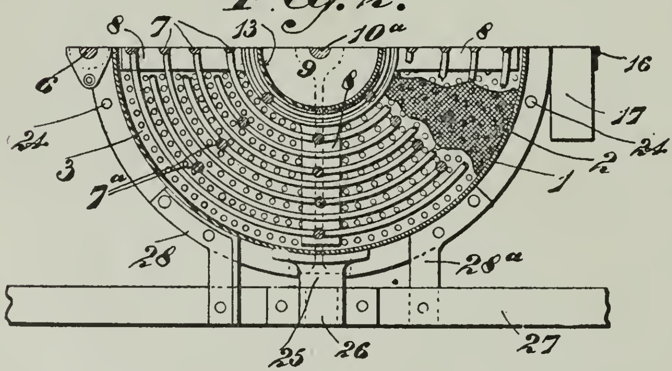
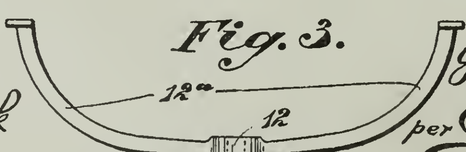


Fig. 3.



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(No Model.)

2 Sheets—Sheet 2.

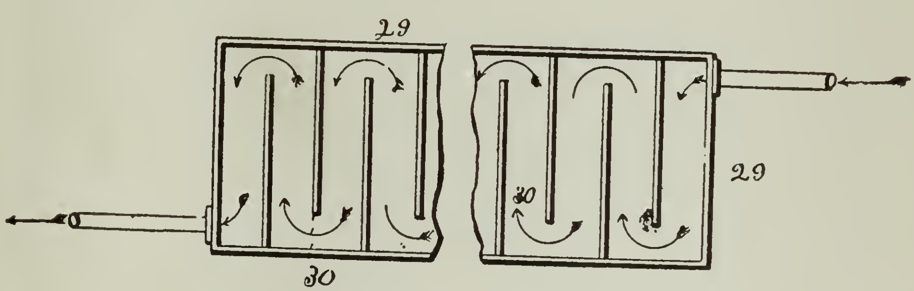
G. ROBSON.

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669.

Patented Jan. 19, 1897.

Fig. 4



Witnesses:
F. C. Barry
C. H. Duffy

Inventor
Geo. Robson.
per O. E. Duffy
Attorney

UNITED STATES PATENT OFFICE.

GEORGE ROBSON, OF DOLGELLY, ENGLAND, ASSIGNOR TO HIMSELF, AND SAMUEL CROWDER, OF LONDON, ENGLAND

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

SPECIFICATION forming part of Letters Patent No. 575,669, dated January 19, 1897.

Application filed July 18, 1894. Serial No. 517,937. (No model.) Patented in England January 8, 1894, No. 427; in Transvaal April 2, 1894, No. 617; in France July 5, 1894, No. 239,819; in Germany November 24, 1894, No. 82,722; in Victoria October 29, 1895, No. 12,628; in New South Wales October 31, 1895, No. 6,163; in South Australia October 31, 1895, No. 3,075, and in New Zealand November 5, 1895, No. 8,035.

To all whom it may concern:

Be it known that I, GEORGE ROBSON, a subject of the Queen of Great Britain and Ireland, residing at Llanfachreth, Dolgelly, North Wales, United Kingdom of Great Britain and Ireland, have invented an Improvement in the Separation of Metals and Metallic Compounds from Ores or other Substances, (for which I have obtained Letters Patent in England, No. 427, dated January 8, 1894; in France, No. 239,819, dated July 5, 1894; in Germany, No. 82,722, dated November 24, 1894; in Victoria, No. 12,628, dated October 29, 1895; in New South Wales, No. 6,163, dated October 31, 1895; in South Australia, No. 3,075, dated October 31, 1895; in New Zealand, No. 8,035, dated November 5, 1895, and in Transvaal, No. 617, dated April 2, 1894,) of which the following is a specification.

This invention has for its object to separate and recover, in an economical manner, finely-divided metal and metallic compounds, such as sulfids and metallic oxids present in finely-divided substances, such as crushed ores, slimes, and the refuse matter, such as the tailings, float matter, and the like, carried away by the water used in the washing and dressing of metalliferous ores and earths, as in crushing-machines, buddles, jigging-machines, vanning-machines, and the like. For this purpose the substances containing finely-divided metal or metallic compounds such as referred to, or both, (hereinafter referred to as metallic matter,) are brought into intimate contact with an oily liquid that is of less specific gravity than water, and is capable of taking up the said finely-divided metallic matter and thus separating it from the substances with which it was previously mixed.

I have found by experiment that a suitable liquid for the purpose mentioned can be obtained by mixing a liquid hydrocarbon, such, for example, as turpentine, petroleum, paraffin, or the like, with a fatty oil such as colza-oil, the proportion of fatty oil in the mixture varying say, for example, from about ten to twenty-five per cent. of the hydrocarbon, according to the nature of the material to be treated. For example, when treating quartz containing gold and iron oxid for the recovery of the gold a smaller quantity, say ten per cent., of fatty oil should be used than when iron oxid is absent, in order that the iron oxid may not be removed with the gold. I prefer to use as the liquid hydrocarbon a mineral oil such as petroleum or paraffin on account of its cheapness. The fatty oil appears to play the principal part in the actual separation of the metallic matter, the liquid hydrocarbon acting the part of a diluent.

In carrying out my invention the finely-divided substances can, in a soft and plastic state, be brought into contact with the mixture of oils (hereinafter referred to as the oily liquid) in various ways. Thus the said substances in a moist or pasty state, due to admixture therewith of a small quantity of water, say from about twenty-five per cent. to thirty-five per cent. of water, may be mixed or agitated with the oily liquid in a suitable vessel in such a manner that the metallic matter present in the resulting mud or mass will be brought into intimate contact with the oily liquid, so as to be taken up thereby and be then carried to the surface of the mass, whence it can be run off, with a portion of the oily liquid, into a suitable settling vessel or separating device wherein the metallic matter is allowed to subside or is separated and from which the oily liquid is withdrawn for reuse.

In the accompanying drawings, Figure 1 is a vertical section, and Fig. 2 a half-sectional plan showing an arrangement of apparatus suitable for thus carrying out my invention. Fig. 3 is a detail view. Fig. 4 is a part plan of a settling vessel.

The apparatus, Figs. 1, 2, and 3, comprises a vessel 1, provided with a false bottom consisting, preferably, of finely perforated or reticulated sheet material 2, held between two stronger and coarsely-perforated plates 3, the space between this false bottom and the true bottom 1^a of the vessel forming a delivery-

chamber 4, that is placed by a pipe 5 in communication with a pump 6 for supplying the oily liquid thereto

5^a is an exit-pipe for running off oily liquid laden with metallic matter into a separating device

5^b is a pipe normally closed for draining off the oily liquid remaining in the vessel at the termination of the treatment of a charge of material.

Within the vessel are arranged two series of vertical stirring-rods 7 7^a, arranged to revolve in concentric circles and carried by horizontal arms 8 8^a, extending, respectively, from hubs 9 9^a, fixed to or formed in one, with two rotary shafts 10 10^a extending through the bottom of the vessel The shaft 10 passes through a stuffing-box 11 and is carried by a step-bearing 12, formed by the central portion of a curved bracket 12^a, (shown separately in Fig. 3,) the ends of which are secured to the bottom of the vessel The hub 9 of this shaft may advantageously be provided with a centrally-arranged tubular extension 13, through which the shaft 10^a extends and which is closed at the top by a cover 13^a, formed with an annular bearing 13^b, of V shape in cross-section, and adapted to receive a correspondingly-shaped annular ridge on the under side of the hub 9^a and so prevent escape of material at this point. The rotary shaft 10^a extends through the shaft 10 and is carried by a second step-bearing 12^b, formed and arranged similarly to 12.

To the shafts 10 and 10^a are respectively fixed two bevel-wheels 14 14^a, that are in gear with a bevel-wheel 15, that is common to them and which is fixed upon a driving-shaft 16, provided with a driving-wheel 17.

18 is a bevel-wheel in gear with bevel-wheel 14 and fixed upon a shaft 19, having a crank 20, which serves to operate, through a connecting-rod 21, the pump 6, which may be of any suitable kind, such as a single or double acting plunger pump. The bearings 22 of the two shafts 16 and 19 are carried by a plate 23, which is suspended from the bottom of the vessel 1 by bolts 24 and is slotted at 23^a to accommodate the bevel-wheels 15 and 18.

To enable the bottom 1^a to be readily removed for gaining access to the chamber 4, the said bottom may conveniently be secured in place by nuts 24^b on the bolts 24 and the stuffing-box 11 be unprovided with the usual flange at its outer end, so that upon loosening the said nuts and the nuts upon the gland-studs the bottom can be lowered to an extent limited by the stuffing-box gland 11^a. The vessel is provided with trunnions 25, mounted in bearings 26, fixed upon two beams 27, so that it can be partly rotated, when necessary, to discharge its contents, at which time the driving-belt is removed from the driving pulley 17.

28 28^a are two brackets fixed to the vessel and adapted to bear against the upper and lower sides, respectively, of one of the beams to which they are fixed by bolts to hold the vessel steady when the stirring mechanism is in operation.

The exit-pipe 5^a is arranged to deliver the oily liquid escaping from the top of the vessel into a separator having its outlet in connection with the suction of the pump 6, the arrangement being such that oily liquid can be caused to flow continuously through the finely divided and agitated substances in the vessel 1 and then be delivered with metallic matter taken up thereby into the separator, wherein such matter is separated from the oily liquid, which is drawn off by the pump for reuse.

In carrying out the invention the cover 13^a of the vessel 13 is removed, the finely-divided metalliferous substances in the form of a soft plastic mass, produced by previous admixture of water therewith, as set forth, is placed in the vessel, the cover replaced, the stirring-rods 7 7^a set in motion, and oily liquid circulated continuously through the vessel and separator. By the agitation of the plastic mass with the oily liquid the finely-divided metallic matter present therein is brought into intimate contact with the oily liquid, which takes it up and carries it off from the gangue or earthy matter present, which, owing to its admixture with water, forms a soft plastic mass that is of greater specific gravity than the oily mixture and which is not disintegrated by and consequently disseminated through and carried off by the oily liquid. In this way the finely-divided metallic matter is separated from the gangue and floated or carried off by the oily liquid into the separator, where it is allowed to deposit by gravity, the gangue remaining in the form of a soft plastic mass at the bottom of the mixing vessel

The separating device may conveniently consist of a settler of ordinary construction, consisting of a vessel 29, Fig. 4, provided with divisions or baffles 30, so as to form a zigzag course for the oily liquid, and in which the metallic matter is allowed to separate from the oily liquid by gravity, the oily liquid running off clear for reuse.

I am aware that it has been proposed to recover finely-comminuted metal from ores by the use of oils mixed with acids or salts by mixing the finely-divided ores with oils and acids or salts and afterward washing out the gangue with water, and also of mixing the ores with oils and then washing out the sand or gangue with water containing acid. I disclaim the use of acids or salts and also the method of washing away the gangue with water, both these methods being entirely dissimilar to the method herein described as constituting my invention, according to which I effect the separation of the metallic matter by the mixture of oils alone, using such mixture to wash out the metallic matter and avoiding as far as possible the presence of water much in excess of the quantity hereinbefore mentioned, as I find an excess of water

prevents the successful carrying out of my invention.

It has been found that the oily mixture has an affinity or cohesion with the metallic particles greatly exceeding that for the nonmetallic particles, so that when motion is imparted to the oil the traction of the oil, due to the aforesaid cohesion, is sufficient to overcome the gravital tendency of the metallic particles, while its cohesion for the nonmetallic particles is insufficient to overcome the gravital tendency of said non-metallic particles. It follows that when such motion has been imparted to the oil the traction on the metallic particles is sufficient to carry such particles up while the non-metallic particles remain behind, a separation of the two being thus effected, the metallic particles being afterward separated from the oily mixture.

What I claim is—

1. The herein-described mode of separating and recovering finely-divided metal and metallic compounds from finely-divided substances, which consists in intimately and thoroughly mixing said substances with a diluent liquid containing a fatty substance so that the metallic portions are taken up by the fatty substance then removing the oily liquid with metallic matter from the said finely-divided substances and then separating the metallic matter from said oily liquid, substantially as herein described.

2. The method of recovering metals and metallic compounds from finely-divided substances, which consists in thoroughly and mechanically agitating and mixing a fatty oil with said substances while the same are in a moist or plastic state due to admixture of water therewith, then drawing off the fatty oil carry the metal particles, and metallic compounds from said substances, and then separating the metals and metallic compounds from the oil, substantially as described.

3. The herein-described mode of recovering metals and metallic compounds from finely-divided substances in a moist state, which consists in passing oil through the mass of finely-divided material so that the oil floats off the metallic portions against the force of gravity, and removing the oil carrying said metallic particles and separating the metallic portions therefrom, substantially as described.

4. The herein-described method of separating and recovering finely-divided metal and metallic compounds from finely-divided substances which consists in forming said finely-divided substances into a moist or pasty mass by admixture therewith of water, floating off finely-divided metallic compounds from said mass by agitating the same with an oily liquid, drawing off the oily liquid, and separating therefrom the metallic matter carried off thereby, substantially as described.

5. The herein-described method of washing out metals and metallic compounds from finely-divided substances, which consists in causing an oily liquid to flow in a practically continuous stream through the said substances while the same are in a stirred or agitated state, separating the metallic matter from the oily liquid by gravity after it has been removed from the said substances, and afterward again bringing the oily liquid into contact with the said substances for reuse, substantially as herein described

6. The combination of the horizontal supporting-beams, the closed separating vessel having the inlet and outlet pipes and the driving-gear at its lower end, said vessel having the lateral trunnions journaled in said beams and the lateral arms 28 and 28^a above and below the planes of the beams as and for the purposes described.

7. The combination of the outer casing, the vertical shaft passing therethrough and at one end of the casing, having the disk provided with stirring-arms extending longitudinally of the casing, a sleeve on said shaft and turning oppositely thereto, a disk in the casing or the sleeve having the stirring-arms extending longitudinally of the shaft and between the first-mentioned stirrer-arms, brackets at the lower end of the casing having bearings for the lower ends of the sleeve and shaft, and gears on the sleeve and shaft provided with means for driving them in opposite directions, substantially as described.

8. For separating and recovering metallic matter from finely-divided substances containing the same, apparatus comprising a pivoted vessel having a perforated or reticulated false bottom and inlet and outlet passages for oily liquid, stirrers arranged within said vessel, a pump carried by said vessel and adapted to cause oily liquid to flow therethrough and mechanism carried by said vessel for driving said stirrers and pumps substantially as herein described.

9. In a separator, the combination of the cylindrical casing, the central longitudinal shaft therein, the disk on the shaft at one end of the casing having the stirrers, the sleeve turnable on the shaft, the disk on said sleeve in the opposite end of the casing having the stirrers extending between and parallel with the opposite stirrers, the central closed longitudinal cylinder 15, between and engaging said disks, and gearing rotating the sleeve and shaft in opposite directions, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses

GEORGE ROBSON

Witnesses:

PERCY ERNA HOCKS,

EDMUND S. SNEWIN.

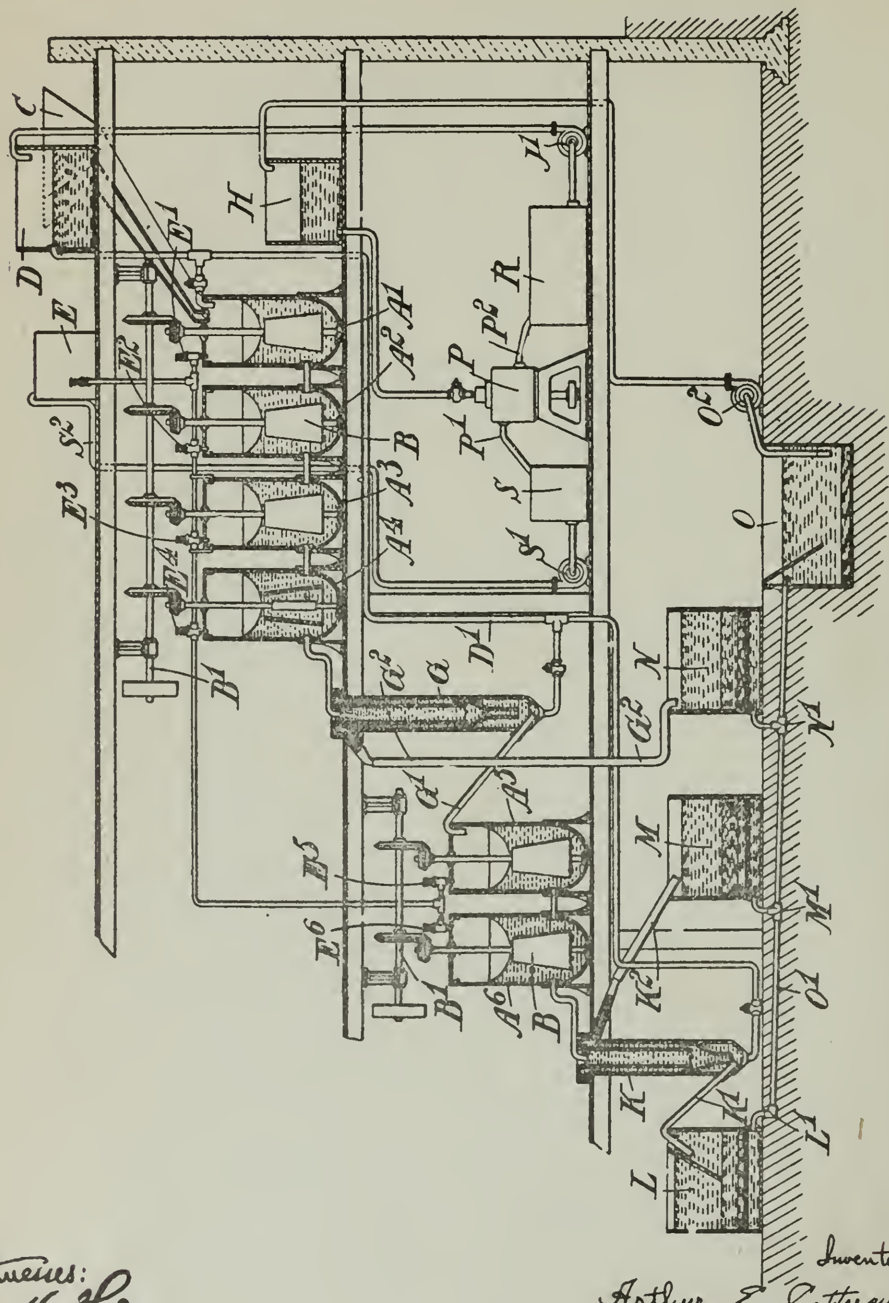
No. 763,259. PATENTED JUNE 21, 1904.

A. E. CATTERMOLE.

CLASSIFICATION OF THE METALLIC CONSTITUENTS OF ORES.

APPLICATION FILED SEPT. 29, 1903.

NO MODEL.



Witnesses:

Inventor:

Arthur E. Cattermole.

UNITED STATES PATENT OFFICE.

ARTHUR EDWARD CATTERMOLE, OF LONDON, ENGLAND.

CLASSIFICATION OF THE METALLIC CONSTITUENTS OF ORES.

SPECIFICATION forming part of Letters Patent No. 763,259, dated June 21, 1904.

Application filed September 29, 1903. Serial No. 175,060. (No specimens.)

To all whom it may concern:

Be it known that I, ARTHUR EDWARD CATTERMOLE, a subject of the King of England, residing at London, England, have invented certain new and useful Improvements in the Classification of the Metallic Constituents of Ores, of which the following is a specification.

The present invention relates to the classification of the metalliferous constituents of ores which have been separated from gangue by oil or similar matter, such as certain wood or coal tar products, hereinafter referred to as "oil," in which term I also include the emulsifying agent when an emulsifying agent is present with the oil.

The invention consists in fractionally removing the different constituents from the agglomerated masses by freeing the constituents in turn from the oil, and thus obtaining them in a separable condition by the use of emulsifying agents of varying strength and activity, preferably in conjunction with an alkali.

In carrying out the process the metalliferous mineral matter agglomerated by oil is mixed and agitated with a solution of an emulsifying agent, such as a soluble soap—alkaline oleate, for example—to which a certain proportion of soluble alkali, preferably caustic potash or soda, has been added.

It is found that minerals vary in their affinity for oil employed in the above manner, and thus by treating the oily masses or granules in the first place with an alkaline emulsifying solution of a certain strength the mineral of least affinity can be separated therefrom and by increasing the strength or modifying the proportions of the breaking-down solution step by step the various metalliferous constituents may be thrown out in the order of their increasing affinities. Taking, for example, an ore containing siliceous gangue, rosin-blende, copper pyrites, and galena, the ore is first treated with oil or emulsified oil for the granulation of the metalliferous mineral. The oil is preferably one such, for example, as a hydrocarbon oil which is not too readily emulsified and which gives a wide range of strength in the solutions required for breaking down the granules. The compound granules separated from the siliceous gangue and liquor are drained and run into the first classifying apparatus, where they are agitated with a solution, which may have, say, a strength of three-fourths of one per cent. soap (when this is the emulsifying agent employed) and of three-fourths of one per cent. alkali, by which the rosin-blende is dropped out. The granules remaining freed from blende and liquor are then passed onto a second similar apparatus in which a solution of a strength of, say, one and one-half per cent. soap, one and one-half per cent. alkali is used. Here the copper pyrites is freed and subsequently removed, the galena remaining still granulated. The oil may finally be recovered from these granules by the use of a solution of suitable—*i. e.*, sufficient—strength of alkali and emulsifying agent, and its separation from the mineral may be promoted by attrition.

The strength of the breaking-down solutions required and the relative proportions of their constituents depend mainly upon the following conditions—that is to say, upon the state of fineness of the ore treated, the relative proportions of the contained minerals one to another, their physical condition and chemical composition, the nature of the oil, emulsifying agent, and alkali used.

The example above given indicates for an ore such as is there supposed to be under treatment and for the oil and emulsifying agent mentioned in what proportions these agents should be employed. In the case of another ore and of other reagents these proportions may need to be readjusted, and for the purpose of such readjustment the following rules may be laid down. The finer the ore the more compact and cohesive are the granules formed from it, other things being equal, and therefore stronger breaking-down solution will be required with a finely-ground ore than with one coarsely ground. With granules where minerals, such as galena, which offer great resistance to the breaking-down action of the solution preponderate the breaking-down so-

lution should of course be stronger or more active than in the alternative case, (where mineral such as rosin-blende, which offers less resistance to the breaking-down solution preponderates.)

In considering the chemical composition of the minerals it is of course necessary to bear in mind that a constituent mineral—say, for example, zinc-blende—may contain impurities or other metalliferous constituents (such as iron sulfid) which will materially affect their resistance to the breaking-down action of the solution, in the case supposed increasing such resistance.

With regard to the nature of the oil. With the animal or vegetable oils or readily-emulsified oils the breaking down is comparatively rapid and may be too rapid for conveniently carrying out this process. With heavy residuum oils and other heavy hydrocarbon oils, which are emulsified with difficulty, the breaking down is comparatively difficult and slow. Oils may be blended for the purpose of obtaining a mixture which suits the requirements of any particular mineral mixture which may be under treatment. The breaking down is effected most advantageously with emulsifying agents and alkali which are readily soluble. Bearing these principles in mind, the operator will always be able to determine by observations made in the course of working, or, if he so prefers, by a few simple preliminary tests, under what conditions this process can be worked to the best advantage.

In the upcurrent or other separating device for removing the freed mineral from the granules remaining solution of the same strength as that used in "breaking down" may be employed, or it may be somewhat weakened by dilution, so long as the reagglomeration of the separated mineral does not take place.

The more or less emulsified oil removed from the granules separates out as a "cream" or concentrated emulsion from the breaking-down solution employed, and the separation of such oil for reuse in the various stages and recovery of oil-depleted solution for reuse in the breaking-down stage may be hastened by the employment of mechanical separators. Since oil is being removed in each breaking-down stage, it is generally preferable to start with the compound mineral granules in a rather soft or pasty condition by the use of a sufficiency of oil in the granulating stage, or, if necessary, the granules from one stage if reduced too small by removal of oil for ready separation may be again treated with oil or oil emulsion, or oil or oil emulsion may be added to the breaking-down solutions in the requisite small amounts to keep the granules of proper size and consistency to be dealt with in the separating devices in use. The presence of a certain amount of oil in the solutions assists separation by preventing the too ready breaking down of the granules.

The separated minerals may be drained or treated in centrifugal or other mechanical solution-extractors for the closer recovery of solution and drying of the product.

The accompanying drawing is a diagram illustrating in sectional view one method of carrying out the process according to this invention as applied to a mixed sulfid ore—Broken Hill ore, for example—consisting of galena and blende.

A series of connected mixing vessels A A A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving-shafts B'. The oily granulated mixture of galena and black blende freed from the gangue from the hopper C and breaking-down solution, which may have a strength of one-half of one per cent. alkaline oleate and one and one-half per cent. caustic alkali, from a tank D are introduced into the first vessel A', and the oil or emulsion needed to keep the granules of suitable size and consistency is fed as required from the tank E through pipes and regulating-taps E' E^2 E^3 to the various vessels. The mixture is vigorously agitated to break down the mixed granules and liberate the blende. After agitating to a certain extent (in four communicating vessels, as illustrated, for example,) the mixture is passed into an upcurrent classifier G, which is supplied with solution from the tank D through a pipe D'. The partly-broken-down granules and the heavier particles of liberated blende are discharged through a pipe G' into the vessel A^5, while the lighter particles of blende are carried away by the upward current and discharged through outlet-pipe G^2 to the tank N, provided with a filter-bottom for the draining of the product. The solution is allowed to run by the pipes N' and O' into a tank O, from which the solution may be returned by the pump O^2 to the tank H. The granules and coarser blende are subjected to further agitation in the vessels A^5 A^6, where the separation of the blende is completed, and are then passed into a second classifier K, from which the galena granules are removed at the bottom by the pipe K' into the tank L, while the blende is discharged from the upper pipe K^2 into the tank M. Like N the tanks L M are provided with a filter-bottom, and the solution that drains away is led by the pipes L' M' and pipe O' into the tank O for pumping up to the tank H. The solution thus returned to this tank contains the oil removed from the granules and is thence run into a centrifugal separator P, whence the oil escapes through a pipe P' to a tank S, while the solution, deprived more or less completely of oil or oil emulsion, runs into a tank R and is thence returned by the pump J' to the feed-tank D for reuse. The separated oil or oil emulsion in the tank S is returned by the pump S' through a pipe S^2 to the oil or emulsion tank E. This apparatus is illustrated only as one convenient method of carrying out this invention and it is to be un-

derstood that its nature and arrangement can be considerably varied.

The process, it will be seen, comprises two steps which are essentially distinct—first, the removal of certain constituents from the agglomerated masses or granules, and, second, the separation of the material so removed from the remaining granules. In the apparatus described and illustrated in the accompanying drawing, I have provided for the carrying out of these two stages of the process in separate vessels, (mixers and separators, respectively;) but it will be readily understood that the apparatus and process can, if desired, be so modified that all the operations may be carried on in a single vessel, and similarly the various parts of the apparatus may be modified in a great many ways to suit special conditions of working.

In some cases, as when one of the mineral constituents is small in amount, particularly when among the last to be separated, it may be increased up to the required point for ready separation by incorporating the requisite amount with the initial mixed granules or by addition to the product in the apparatus in which the breaking down is effected. A certain amount of already-separated mineral may be returned for this purpose, or where, owing to the absence of sufficient fine or slime material weakly-coherent granules breaking down too readily are obtained, such fine mineral may be added, as described, to render such granules more coherent and resistant. In other cases with the same object in view it may be advantageous to subject the granulated mixed mineral to grinding action to further reduce the size of the constituent mineral particles without destroying the agglomeration before breaking down and separation of the constituents.

When minerals granulated with some tarry products are treated, an alkaline breaking-down solution with an emulsifying agent of analogous nature may with advantage be employed. For example, when granulated with wood-tar an alkaline solution of the tar of suitable proportions and strength is the most suitable liquor to be employed for breaking down and separation of the minerals.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession.

2. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession separating out each mineral in turn by a separating device and adding oil in the requisite small amounts to keep the granules of proper size and consistency.

3. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession.

4. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession and separating out each mineral in turn by an upward current.

5. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession separating out each mineral in turn by an upward current and adding oil in the requisite small amounts to keep the granules of proper size and consistency.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

Witnesses:

HASOP WADE,

HARRY S. GRIDGE.

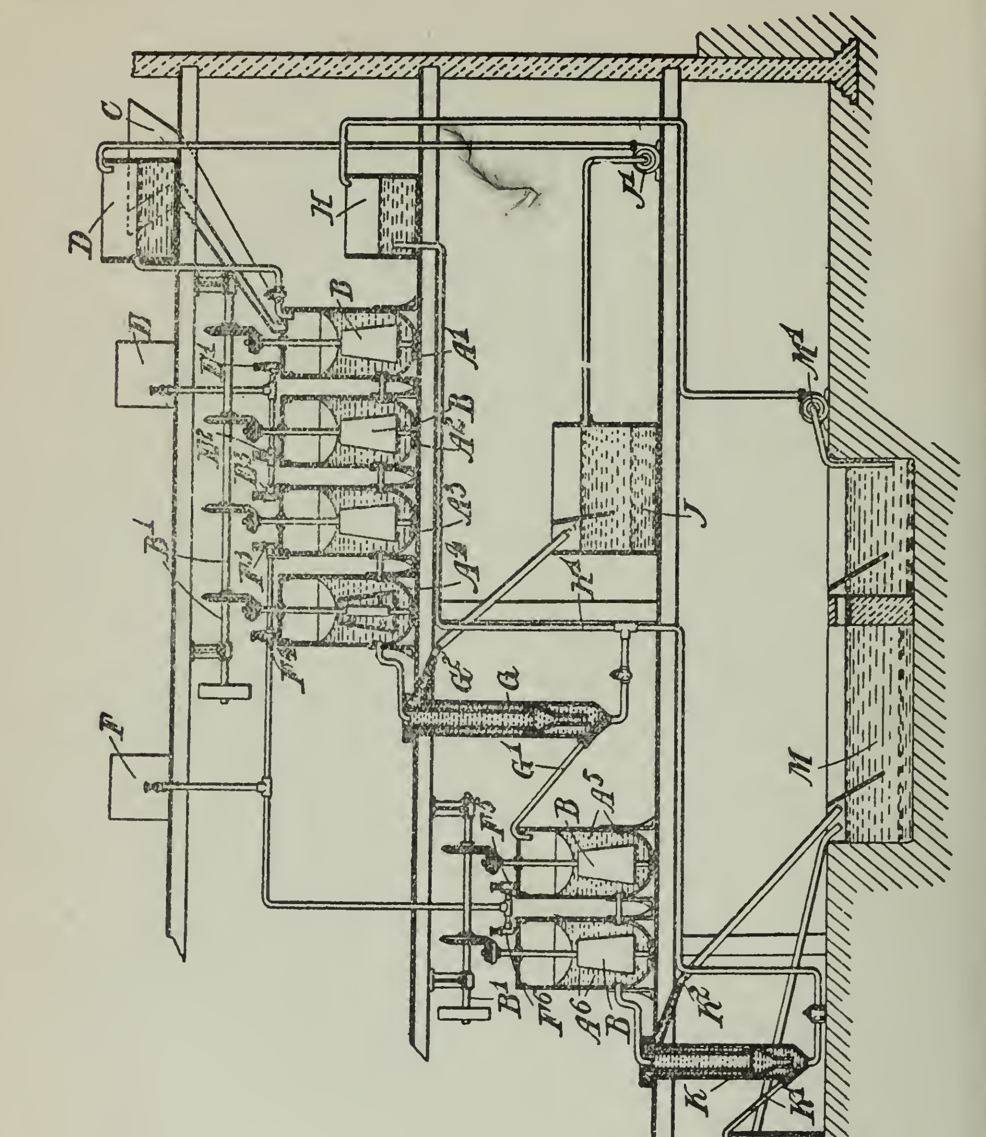
No. 763,260. PATENTED JUNE 21, 1904.

A. E. CATTERMOLE.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

APPLICATION FILED JAN. 2, 1904.

NO MODEL.



Witnesses:

Inventor:
Arthur E. Cattermole

By
Attorneys

No. 763,260. Patented June 21, 1904.

UNITED STATES PATENT OFFICE.

ARTHUR EDWARD CATTERMOLE, OF HIGHGATE, LONDON, ENGLAND.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

SPECIFICATION forming part of Letters Patent No. 763,260, dated June 21, 1904.

Original application filed September 28, 1903, Serial No. 174,947. Divided and this application filed January 2, 1904. Serial No. 187,599. (No specimens.)

To all whom it may concern:

Be it known that I, ARTHUR EDWARD CATTERMOLE, a subject of the King of England, residing at Highgate, London, England, have invented certain new and useful Improvements in the Separation of the Metallic Constituents of Ores from Gangue, of which the following is a specification.

This application is a division of my application filed September 28, 1903, Serial No. 174,947.

The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as "oil") on metallic or metalliferous matter.

The invention depends upon the application of the following facts: First, when a mixture of powdered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water be made alkaline and an emulsifying agent, such as soap, be present, the selective action of the oil will be rendered more marked and decisive; third, if the proportion of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be treated and the consistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated, the metalliferous particles which have become coated with oil will adhere together and form granules, which granules, partly by reason of gravity or partly on account of their bulk as compared with the individual grains of gangue, will offer ready means for separation in an upcurrent-separator, a jig, or other similar appliance. This action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of free soap.

In some cases the pulp may contain mineral acid. Alkali must then be added in sufficient quantity to neutralize the acid and to leave some alkaline soap undecomposed—that is, free.

These facts are utilized for the purpose of separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor containing an alkaline emulsifying agent. As the agitation proceeds the particles of metalliferous matter agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. This granulation of the metalliferous constituents of the ore affords the means by which at a later stage of the process it is possible to separate the metalliferous material from the gangue, as will be hereinafter particularly described. In practice a continuous process is used—that is to say, water, ground ore, or pulp and oil, preferably emulsified, are continuously fed into a series of vessels and the products of the agitation are continuously fed into an upcurrent-separator or jig or similar device which in the case of the upcurrent-separator separates the metalliferous granules from the gangue by allowing them to fall to the bottom of the vessel and to be carried away by a downward stream, while the particles of gangue are carried away by an upward stream.

The accompanying drawing is a diagram illustrating in sectional view one means of carrying out the process according to this invention.

A series of connected mixing vessels A' A² A³ A⁴ A⁵ A⁶ are provided with stirrers B, rotated from driving-shafts B'. Crushed ore from a hopper C and circuit-water from a tank D are introduced into the first vessels A', and oil or emulsion is fed from a tank E, through pipes E' E² E³, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and to bring about in-

timate contact of the divided oil with the metalliferous mineral particles and of the oiled particles with each other. An alkaline emulsifying agent, such as soap, is introduced into one or more of the vessels from a tank F, having discharge-pipes F^3 F^4 F^5 F^6. It is found under these conditions that the metalliferous mineral particles abstract the oil and become coated with a thin oily film which is insufficient to materially lessen their specific gravity and that under agitation such slightly-oiled particles adhere, nucleate, and agglomerate into small more or less rounded masses or granules disseminated throughout the mass of gangue, which remains free and practically devoid of oil. After agitation to a certain extent (in four vessels, as illustrated, for example) the mixture is passed into an upcurrent-classifier G, which is supplied with a stream of circuit-water from a tank H through a pipe H'. As the granules remain specifically heavier than the gangue or can by suitably adjusting the amount of oil and the agitation be obtained of a size larger than that of the gangue particles, the granules, with a certain amount of heavy sands, sink to the bottom and are discharged through a pipe G' into vessel A^6, while the lighter sands are carried away by the upward current and discharged through outlet G^2 to a light-sands tank J, from which the circuit-water may be returned by a pump J' to the feed-tank D for reuse. In order to separate the granules from the heavy sands, the mixture is subjected to further agitation in the vessels A^5 A^6 and is then passed into a second classifier K, from which the granules are removed at the bottom by the pipe K' into the metalliferous-mineral tank L, while the heavy sands are discharged from the upper pipe K^2 into a heavy-sands tank M. The circuit-water from the tanks L and M is returned by a pump N' to the feed-water tank H. This apparatus is illustrated only as one convenient method of carrying out this invention, and it is to be understood that its nature and arrangement can be considerably varied.

The water throughout the circuit is alkaline and contains a suitable proportion of soap or other emulsifying agent. The agitation vessels may be separate, with arrangements for charging and discharging, the charging with pulp and the addition of oil or emulsified oil and the agitation and discharge successively in the series of vessels being so timed that the output of treated ore is kept continuous and constant. The classifiers used may be jigs, shaking-tables, or the like or sizing apparatus whereby the comparatively larger mineral granules may be separated from the finer gangue, and one or more classifiers may be employed.

The proportion of oil used depends upon its viscosity, the fineness of the ore, and other factors, and the consistency and size of the mineral granules desired. The more oil used the larger, softer, and less numerous the granules. With, say, ten per cent. of oil to the weight of metalliferous mineral a few pasty masses of oil agglomerated metalliferous mineral matter will generally result. Oil in excess of this may cause all the granules to coalesce into one soft mass. Usually an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the upcurrent or other apparatus used for classification

The amount of emulsifying agent, if used to form the oil-emulsion, depends upon the viscosity and nature of the oil. When soap is employed, an amount varying from three per cent. to five per cent. of the weight of oil usually suffices, this being dissolved in, say, ten times its weight of water. For emulsification a low alkalinity of the emulsifying agent is generally best.

The oil used may be animal, vegetable, or mineral oil, or mixtures of these, or such coal or wood tar products or other substances which exercise, like oils, a preferential physical affinity for metallic mineral matter as distinguished from gangue.

The emulsifying agent may be any substance capable of holding the oil in a fine state of division in suspension in water without acting on the mineral matter or preventing the action of the oil—for example, soap, alkaline cresylates, or other substances solutions of which in water froth on agitation. The emulsifying agent appears to have a decided effect in bringing about the granulation as described. In some cases, as with wood-tar and some coal-tar products, these when agitated in weak alkaline solutions provide their own emulsifying agents, soluble resinates, cresylates, &c., being thereby formed, which emulsify the bulk of the tar or product.

Emulsification in some cases, as with the heavier residuum oils or tars, may be assisted by first mixing therewith a small amount of fatty oil or fatty acid. Preferably one emulsifying agent is employed throughout the process.

In order to recover the oil from the granules after their separation from the gangue, they may be agitated with the emulsifying agent in a stronger or more active condition or proportion than was used in the emulsification of the oils initially, and the action of this emulsifying agent in stripping the oil from the metalliferous mineral particles may be aided by attrition. The strengthening of the emulsifying agent may be effected by increasing the proportion of the agent or of the alkaline base in solution, or both, the percentage strength of the solution needed depending upon the oil used and the nature of the metalliferous mineral matter with which it is

associated. Usually if oleic soap is employed and caustic potash amounts varying from one-quarter of one per cent. to three per cent. or four per cent. of one or the other in solution suffices, the less readily emulsified oils, as the residuum oils, requiring the larger amounts. The removed oil is obtained as a dilute emulsion, which on standing some time separates. The "cream" or concentrated emulsion may then be used for making fresh emulsion for treating fresh ore. To hasten this separation of cream. mechanical devices may be employed.

Generally with wet crushed ore removal of the bulk of the water for reuse in the mill is necessary. In such case the pulp is settled and the wet ore only fed into the agitators, emulsifying agent of suitable strength being added to thin them. The circuit of such liquids can thus be kept distinct from that of the mill-water, suitable arrangements being made for settling the mineral-depleted sands and slime and for addition of emulsifying agent and fresh water as required from time to time.

In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment.

In carrying out the process the ore may be roughly sized into two or more parts, which are then treated separately. With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral.

It is preferable to use circuit-waters of varying degree of alkalinity, according to the nature of the mineral being treated, provided always that about one-half of one per cent. of soap or other emulsifying agent is present.

It is found advisable to keep the amount of free alkali low in proportion to the free soap present when such is the emulsifying agent used. Thus in one example 0.25 per cent. of free soap with 0.025 per cent. of free alkali was sufficient to keep calcite free from oil, 0.3 per cent. free soap and 0.08 per cent. free alkali kept quartz free from oil, while rather stronger solutions—as, for instance, 0.5 per cent. free soap and 0.05 per cent. free alkali—prevented garnet from becoming oil-coated. These figures refer to cases where a light oil was used—namely, paraffin. When the free soap was increased to about one per cent. or when the free alkali was increased to about one-fourth of one per cent., difficulty was found in agglomerating certain metalliferous substances, such as resin-blende and iron or copper pyrites. Care must therefore be taken that neither the soap nor the alkali is in excess of that required for preventing agglomeration of the gangue.

I am aware that the selective action of oils and the like on metallic matter has been made the basis of previous processes for separating the metalliferous constituents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

2. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to up-current classification to remove the small non-coated particles from the granules.

3. The herein-described process of separating metalliferous matter from gangue, which consists in forming granules by agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, separating out the light sands, and thereafter further agitating the pulp to increase the size of the granules and separating out the heavy sands from the granules.

4. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

Witnesses.

CHRISTOPHER BARNETT.

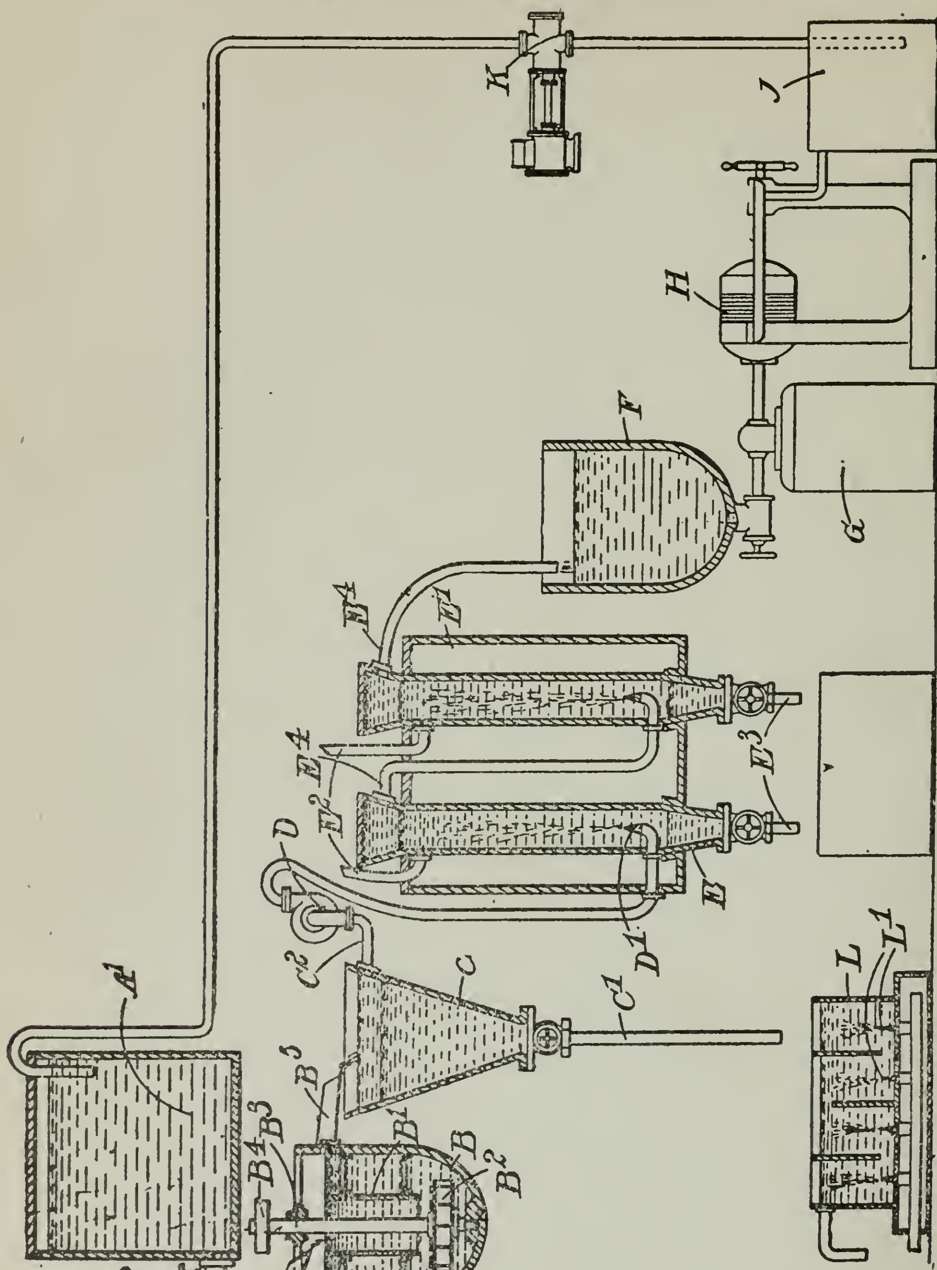
WALTER J. SKERTEN.

No. 787,814 PATENTED APR. 18, 1905.

J. D. WOLF.

SEPARATION OF METALS FROM THEIR ORES.

APPLICATION FILED MAY 22, 1903.



Witnesses

Inventor

Jacob D. Wolf

No. 787,814. Patented April 18, 1905.

UNITED STATES PATENT OFFICE.

JACOB DAVID WOLF, OF LONDON, ENGLAND.

SEPARATION OF METALS FROM THEIR ORES.

SPECIFICATION forming part of Letters Patent No. 787,814, dated April 18, 1905.

Application filed May 22, 1903. Serial No. 158,346.

To all whom it may concern:

Be it known that I, JACOB DAVID WOLF, a citizen of the United States, residing at London, England, have invented certain new and useful Improvements in the Separation of Metals from Their Ores, of which the following is a specification.

The present invention relates to improvements in obtaining metals from their ores, the object being to separate the valuable and metallic-mineral constituents of an ore from its gangue by the use of oil or grease, particularly oil or grease which has been treated with chlorid of sulfur.

According to this invention the ore-pulps are agitated with oil, preferably mineral oil mixed with viscous animal or vegetable oil and treated with chlorid of sulfur, until the oil has taken up all the metallic-mineral contents with some gangue. The mineral-bearing oil is separated from the pulps, and suspended particles of gangue are removed from the oil by passing it through warm water, the metallic minerals being thereafter separated out from the oil, which can be used again. At the same time oil is recovered from the waste pulps by blowing air through them.

In order to increase the viscosity of certain mineral oils, a small proportion—say five per cent.—of animal oil, such as lard-oil, may be added before sulfo-chlorinating. Vegetable oils—such as rape, castor, or linseed oil—act in a similar manner. With pulps having a large proportion of mineral, as in the case of copper, lead, or zinc ores, the prepared oil should be made thick and viscous to produce the necessary power of flotation; but with pulps in which the percentage of mineral is small, as with gold ores, the oil need not be thickened to the maximum extent. In the same way if the particles of mineral are coarse the oil should be specially viscous, while with fine particles the oil may be relatively thinner.

The accompanying drawing is a diagrammatic sectional view of apparatus suitable for use in carrying out this process.

In the following description it is assumed that the oil is treated with chlorid of sulfur; but it is to be understood that the same process and apparatus would apply to other suitable but untreated oils.

The ore mixed with water is crushed into a pulp and is introduced by a launder A into a mixer B, the oil, preferably treated with chlorid of sulfur, being simultaneously run in from the tank A′ through the pipe A^2. The mixing vessel B has a vertical hollow cylinder B′ fixed in the middle of it, and below the cylinder is a turbine-wheel B^2 on a vertical shaft B^3, rotatable through the pulley B^4. The mixture of oil and pulps passes into the hollow cylinder B′, and the rotation of the turbine-wheel B^2 causes a rapid circulation of the mixture downward within the cylinder and upward between the cylinder and the vessel B. The liquid is continuously discharged from the mixer through the pipe B^5 and passes into a separating-tank or spitzkasten C. Here the sulfo-chlorinated oil adhering to the mineral of the ore floats, while the gangue remaining in admixture with the water sinks and is removed by the waste-pipe C′. The mineral-bearing oil passes off from the surface through the conduit C^2. The mixture is next forced—for example, by means of a rotary pump D—in at the bottom of a vertical cylindrical vessel E, containing warm water and surrounded by a steam or hot-water jacket E′. The vessel is provided with a water-inlet pipe E^2 and a waste-outlet E^3 at the bottom, and an oil-outlet E^4 is also provided near the top of the vessel. The oil mixture carrying particles of gangue in suspension is passed into the vessel E, preferably through a perforated inlet D′, to break the oil into thin streams or globules, which rise through the warm water and drop out the gangue in their upward course on account of the decrease in viscosity. If desired, two or more of these vessels may be used in series, the mineral-bearing oil being removed from the surface of each vessel. By the means thus provided for eliminating gangue it is possible to treat ores with such a degree of agitation that the whole of the mineral contents are taken up by the oil, accompanied, however, by a not inconsiderable proportion of gangue; but as practically all this gangue is removable from the oil by a

sufficient treatment with hot water much cleaner and sharper concentrates can be obtained than would be the case under any circumstances without such washing. The oil carrying practically only the values is next passed into a receiver F, from which it is forced, by means of a pneumatic forcing apparatus G, into a filter-press H, which may be of any suitable form—for example, of the type now largely used in the treatment of lard, tallow, and similar oils by fullers' earth. The separated oil is received in a tank J and is returned, by means of a pump K, to the oil-supply tank A' to be mixed with fresh quantities of pulps, the process being thus rendered cyclic. The properties of the oil are permanently altered by treatment with chlorid of sulfur; but it may be found advisable to add a further quantity of chlorid of sulfur after the oil has been in use for some time.

The waste pulps removed from the bottom of the settling-tank C are collected in a vessel L. After agitating the pulps with the oil oil-globules, which from various causes are not completely separated by flotation, but remain in the waste pulps, can be largely separated therefrom and recovered by blowing a current of air or air and steam through jets L' upward through the waste pulps. The oil-globules rise to the surface and break, forming a film which is not liable to sink again and can be recovered by skimming or by surface baffles or the like.

It is to be understood that the form of the apparatus used can be varied without departing from this invention. For example, when separating the suspended gangue from the oil any convenient means may be used for passing the oil through warm water, and in removing the oil from the waste pulps currents of air or steam may be produced in any way. Also any other suitable method separating the values from the oil may be adopted.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water and separating metallic minerals from the oil.

2. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water, separating metallic minerals from the oil which can be used again and recovering oil from the waste pulps by blowing air through them.

3. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation and removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water.

4. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water and filter-pressing the oil to separate out the metallic minerals from the oil.

5. The herein-described process of separating metals from their ores which consists in agitating pulps with mineral oil mixed with viscous oil and treated with chlorid of sulfur until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water and filter-pressing the oil to separate out the metallic minerals from the oil.

6. The herein-described process of separating metals from their ores which consists in agitating pulps with mineral oil mixed with viscous oil and treated with chlorid of sulfur until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water, filter-pressing the oil to separate out the metallic minerals from the oil and removing oil-globules from the waste pulps by spraying jets of air and steam upward through the pulps and skimming off the oil which floats.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JACOB-DAVID WOLF.

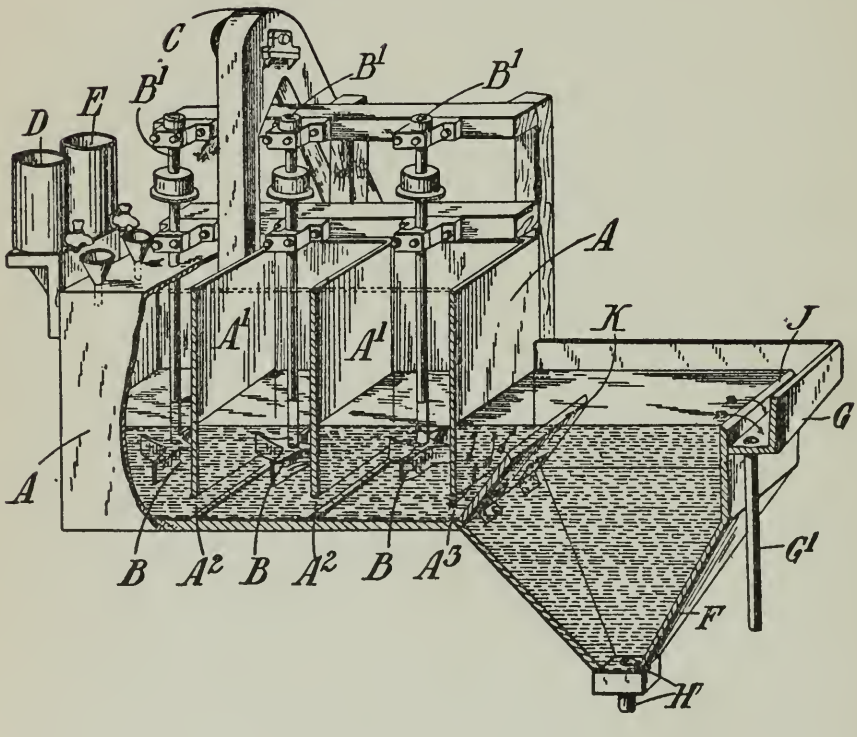
Witnesses:
CLAUDE MCKENZIE,
H. D. JAMESON.

T. J HOOVER.

APPARATUS FOR ORE CONCENTRATION.

APPLICATION FILED MAR. 17, 1909.

953,746. Patented Apr. 5, 1910.



Witnesses
J. M. Wynkoop
Ida P. Stanley.

Inventor
Theodore Jesse Hoover.
By Knight Bro

UNITED STATES PATENT OFFICE.

THEODORE JESSE HOOVER, OF LONDON, ENGLAND, ASSIGNOR TO MINERALS SEPARATION LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR ORE CONCENTRATION.

953,746. Specification of Letters Patent. Patented Apr. 5, 1910.

Application filed March 17, 1909. Serial No. 483.971.

To all whom it may concern:

Be it known that I, THEODORE JESSE HOOVER, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention is applicable to the process described in the United States patent of Sulman, Picard and Ballot, No. 835120, Nov. 6, 1906, in which the liquid wherein the ore is suspended contains a small proportion of oleic acid or other oil. The invention is also applicable to processes in which no oil is used.

When air is beaten into the liquid in which the ore is suspended after which the liquid is introduced into a settling vessel, the object is that the air bubbles rising to the surface of the liquid in the settling vessel should form a froth carrying the particles of metallic sulfids. In certain forms of apparatus hitherto used, a proportion of the air escaped out of the liquid or collected into large bubbles before the liquid was brought into the settling vessel, and some of the effective floating power of the air was therefore lost.

According to this invention, an apparatus for concentrating ores by gaseous flotation of certain mineral particles comprises the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a spitzkasten or like settling vessel placed immediately at the outlet of the agitation apparatus, whereby the air beaten into the liquid is most effectively used for the purpose of flotation.

Another feature of this invention consists in the employment in such an apparatus of a guide, such as a baffle or deflecting plate, arranged at the inlet of the settling vessel in such a way as to direct the stream of mineral particles and air-bubbles toward the surface of the liquid, whereby a particularly effective flotation froth is obtained.

The accompanying drawing is a diagram in perspective, illustrating one form of apparatus embodying this invention.

Several agitation vessels A are placed in series. These may conveniently be large vats separated by partitions A^1 having openings A^2 at the bottom so that the liquid may pass from one to another. Each vessel is provided with a rotatable stirrer B which is conveniently of the form shown in the drawing. Each stirrer is carried on a spindle B^1 rotated at a high speed by any convenient means.

Crushed ore or similar finely divided mineral is fed into the first vessel A through any convenient ore-feeding device such as C, and water is also fed into the vessel A. A small proportion of acid, such as sulfuric acid, may be introduced into the water from the feeding vessel D, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions hereafter specified, may be introduced from the feeding vessel E. The circuit-water may be cold or may be heated to any suitable temperature. The liquid containing ore in suspension is vigorously agitated in the agitation-vessels and escapes at the outlet A^3 highly charged with air.

A settling apparatus consisting of one or more spitzkasten F, is placed immediately at the outlet from the agitation apparatus. As shown in the drawing, the spitzkasten F has a launder G to receive the floating froth which passes away through the outlet G^1. The liquid and the sunken material pass out through the outlet H at the bottom of the spitzkasten. The level of the liquid in the spitzkasten is slightly above the lip J. Within the spitzkasten is placed an inclined baffle or guide-plate K, which may be made adjustable, extending upward from below the inlet A^3 and arranged to direct the stream of ore-particles and air-bubbles toward the surface of the liquid in the spitzkasten. The result of the use of this arrangement is that the liquid passes out of the agitation apparatus directly into the spitzkasten, whereupon the little bubbles of air rise to the surface carrying with them the mineral particles to which they are attached. The fact that the spitzkasten is

placed immediately at the outlet of the agitation apparatus insures that practically all the air introduced into the liquid shall be utilized for flotation purposes and the position of the baffle K assists the air-bubbles in carrying the metallic sulfid particles to the surface while the gangue, which is not attached to the air-bubbles, falls when it passes over the top of the baffle. The liquid which passes out of the bottom of the spitzkasten may, in addition to gangue, contain some metallic sulfids and it may therefore be again submitted to agitation and settling in a similar apparatus.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contents of the agitation vessel so as to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

2. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contents of the agitation vessel so as to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

4. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

5. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined adjustable guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:

H. D. Jameson,

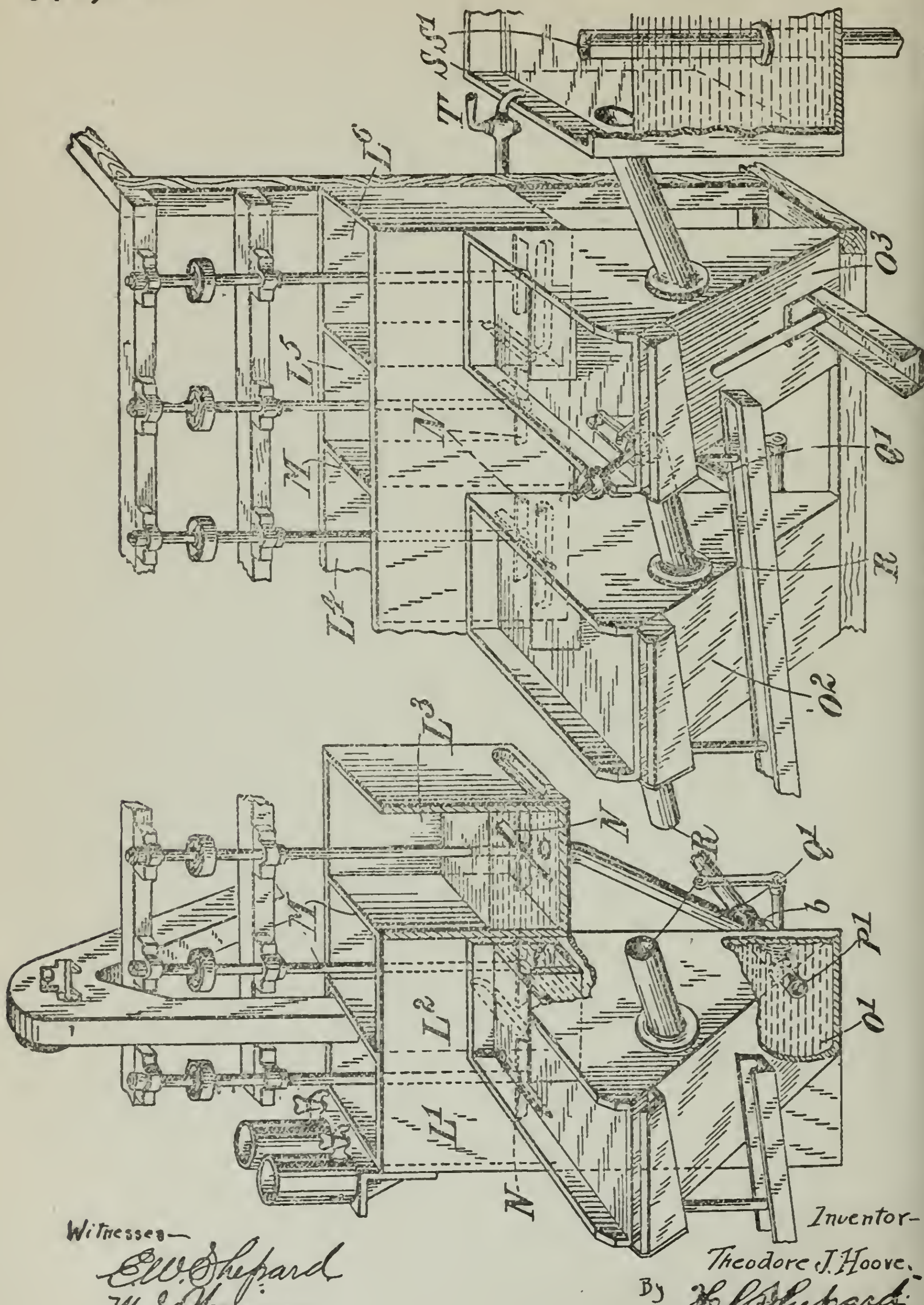
F. L. Rand.

T. J. HOOVER.

APPARATUS FOR ORE CONCENTRATION.

APPLICATION FILED JULY 14, 1910.

979,857. Patented Dec. 27, 1910.



Witnesses—
E.W. Shepard
M. J. Hassmer

Inventor—
Theodore J. Hoover
By H. J. Shepard
Atty

UNITED STATES PATENT OFFICE.

THEODORE JESSE HOOVER, OF LONDON, ENGLAND, ASSIGNOR TO THE MINERALS SEPARATION LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR ORE CONCENTRATION.

979,857. Specification of Letters Patent. Patented Dec. 27, 1910.

Application filed July 14, 1910. Serial No. 571,989.

To all whom it may concern:

Be it known that I, THEODORE JESSE HOOVER, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention will be best understood with reference to the accompanying drawing which is a diagrammatic illustration of one form of apparatus.

Referring to the drawing several mixing vessels (say six) L^1 L^2 L^3 L^4 L^5 L^6 are placed side by side. These may conveniently be large vats separated by partitions M. Where several vessels are connected together into a group the partitions have openings at the bottom so that the liquid may pass from one vessel to another. At the end of each group however the partitions are complete. Each vessel is provided with a rotatable agitator or stirrer N which is conveniently in the form of several radial blades (curved or straight) radiating from the bottom of a rotatable vertical shaft. Each agitator is carried by a vertical spindle rotated at a high speed by any convenient means.

Crushed ore or similar finely divided mineral is fed into the first vessel through any convenient ore feeding device and water is also fed into the vessel.

A small proportion of acid, such as sulfuric acid may be introduced into the water, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions specified may be introduced. The liquid containing ore in suspension is vigorously agitated in the vessels. On the lateral wall of the mixing vessel, or of the last mixing vessel of the first group L^2 there is an outlet *a* at the bottom leading directly into a settling apparatus consisting conveniently of a spitzkasten O^1

The spitzkasten is preferably constructed as shown in the drawing but instead of being connected to the end of the mixing vessel it is connected at the side. The liquid and the sunken material pass out through an outlet P^1 at the bottom of the spitzkasten and a conduit Q^1 connects said outlet with an orifice at the center of the bottom of the next succeeding mixing vessel L^3. The rotating agitator therein performs the function of a centrifugal pump and draws the liquid from the spitzkasten O^1 into said mixing vessel L^3. A suitable valved air inlet *b* controlled by a lever is provided as a part of the conduit Q^1 for the purpose of supplying the necessary air to the liquid after leaving the spitzkasten. The pulp may thus pass through a primary mixing apparatus L^1 L^2 thence through a spitzkasten O^1 into a secondary mixing apparatus L^3 L^4 thence into a second spitzkasten O^2 and through a third mixing apparatus L^5 L^6 and a third spitzkasten O^3. The spitzkasten should be all on one level. At a convenient point, say a few inches below the level of water in the spitzkasten, the spitzkasten are connected together by conduits such as short pipes R. By this means the level of water in the spitzkasten is maintained the same so that exactly the required amount of overflow is constantly maintained in each. The bulk of the circuit liquor passes away with the tailings from the bottom of the last spitzkasten.

In order to determine automatically the level of liquid in the spitzkasten, one of the spitzkasten, conveniently the last, O^3, is connected by a conduit as before with a vessel S of large area (the regulating vessel) placed alongside and filled with liquid, conveniently circuit liquor or water.

One convenient way of keeping a constant level in the regulating vessel is to provide an overflow pipe S^1 the open top of which is at the desired level or a pipe can be so placed that it introduces water into the regulating vessel whenever the level falls below the normal. The regulating vessel may simply be provided with a very small supply of water constantly running in through a tap T at a rate arranged to give the necessary overflow in the spitzkasten or the regulating vessel S may have both an overflow pipe S^1 and an inlet of water through tap T.

Modifications may be made in the details of the invention provided always that the spirit of the invention is not departed from.

What I claim as my invention and desire to secure by Letters Patent is:—

1. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessel, a secondary mixing vessel, a centrifugally acting agitator in said secondary mixing vessel and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator of said secondary mixing vessel.

2. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a mixing vessel, an agitator in said mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel, a connecting conduit between the tailings outlet of the spitzkasten and the center of the bottom of said secondary vessel and a centrifugally acting agitator in said secondary mixing vessel.

3. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a plurality of mixing vessels connected as a group, an agitator in each of said mixing vessels, a spitzkasten at the outlet of said group of mixing vessels a plurality of secondary mixing vessels connected as a group, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the spitzkasten and the zone of the suction influence of the centrifugally acting agitator.

4. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a first mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessel, a secondary mixing vessel at substantially the same level as the first mixing vessel, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel.

5. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel a centrifugally acting agitator therein, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel, said conduit being provided with an air inlet.

6. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and at the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel, and a valve controlled air inlet in said connecting conduit.

7. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid. comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten.

8. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten, a vessel of relatively large area connected by a conduit with one of the spitzkasten and means for maintaining constant the level of the solution therein.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:

H. D. Jamison,

N. Williams.

Third Edition.]

A.D. 1860, 23rd *February*. N° 488.

Obtaining Metals from Ores

LETTERS PATENT to William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, for the Invention of "IMPROVEMENTS IN OBTAINING METALS FROM THEIR ORES OR MATRICES."

Sealed the 17th August 1860, and dated the 23rd February 1860.

PROVISIONAL SPECIFICATION left by the said William Haynes at the Office of the Commissioners of Patents, with his Petition, on the 23rd February 1860.

I, WILLIAM HAYNES, of Bank Place, Holywell, in the County of Flint, Metallurgist, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN OBTAINING METALS FROM THEIR ORES OR MATRICES," to be as follows:—

The nature of the Invention is this:—I first grind the ore to powder and sift it, so as to secure its being of the requisite fineness, and then add what I term my "agent." This is composed of certain substances not soluble in water alone, such as bituminous matter, coal tar from gasworks, and such like; for instance gums or gummy matter, such, for instance, as india-rubber and gutta percha, and fatty or oleaginous matters, and having mixed these together I add one part of this mixture to from five to nine parts of the powdered ore, and then I incorporate the whole together by mixing it in a mixing machine; which being done, I add a sufficient quantity of water to cover the whole bulk, and then pass the same into a triturating machine. Here the separation of the metals from the other portion of the ores or matrices commences, and

[*Price 3d.*]

when the earthy or foreign matter has separated from the "agent" & metal, I remove such earthy or foreign matter, and replace it by fresh ore or matrix, and repeat this till I find my "agent" will take up no more metal.

To remove the "agent" from the metal, I put the "agent" and metal in an alkaline solution. and in due time the metal is precipitated and can be removed for use,and the agent used again,the alkaline being crysrallised, and thus removed from it. The earthy or foreign matter thus freed from metallic admixture will often be valuable for commercial purposes. The details of this Invention admit of variation according to the varied circumstances of operation.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said William Haynes in the Great Seal Patent Office on the 23rd August 1860.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, WILLIAM HAYNES, of Bank Place, Holywell, in the County of Flint, Metallurgist, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the 23rd day of February, in the year of our Lord One thousand eight hundred and sixty, in the twenty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Haynes, Her special licence that I, the said William Haynes, my executors, administrators, and assigns, or such others as I, the said William Haynes, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "IMPROVEMENTS IN OBTAINING METALS FROM THEIR ORES OR MATRICES," upon the condition (amongst others) that I, the said William Haynes, my executors or administrators, by an instrument in writing under my, or their or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calender months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said William Haynes, do hereby declare the nature of my said Invention, and in what manner the same is to be per-

formed, to be particularly described and ascertained in and by the following statement, that is to say:—

(I.) The nature of the said Invention, as hath been heretofore described in the Provisional Specification filed on application for the said Letters Patent, consists in this, viz., that having first ground the ore or matrix (or ore and matrix) to powder, and sifted it so as to secure its being of the requisite fineness, I add thereto what I term my "agent," which is composed of certain substances not soluble in water alone, that is, bituminous matter (coal tar from gasworks, and such like, for instance), gums or gummy matter (amongst others, gutta percha, india-rubber, for instance), and fatty or oleaginous matter, and having mixed these together I add one part of the mixture thus made to from five to nine parts of the ore, or ore and matrix, and then I incorporate the whole together by agitation of the same in a mixing machine; which being done, I add a sufficient quantity of water to cover the whole bulk, and if thought desirable, pass the same into a triturating machine, when, upon working the said triturating machine, the separation of the metals from the other portions of the ores or matrices commences, although the separation could be effected in the mixing machine, as is hereafter described; and when the earthy or foreign matter has separated from the agent and metal, which alone remain in union, I remove such earthy or foreign matter, and replace it by fresh ore or matrix, and repeat this till I find my "agent" will take up no more metal. To remove the "agent" from the metal, I put the agent in an alkaline solution, and in due time the metal is precipitated, and can be removed for use, the alkali, if desired, being crystallized, and thus removed from it. The earthy or foreign matter thus freed from the metal, but combined with the alkaline solution, will often be valuable for commercial purposes.

(II.) In order the better to exemplify in what manner the same Invention is to be performed or put in practice, I would further state, that having as aforesaid crushed the ore or matrix, or ore and matrix, by any suitable method adopted for crushing ores and matrices, and passed the same through a sieve or sifting apparatus of 100 meshes to the lineal inch, or thereabouts, I add to the finely divided substance thus obtained, one part, by weight, of my "agent," to from 5 to 9 parts of this sifted ore, if intended to be treated according to my Invention; the variation in the amount of the "agent" in proportion to the quantity of ore being governed by its character, as for carbonaceous ores, 5 parts, or thereabouts, might be sufficient; whilst for sulphates and sulphurets, 7 to 9 parts would be required, according to the predominance of sulphur.

What I term my "agent" is prepared by mixing together some of the substances mentioned in the outset of this Specification; the particular substances chosen being so chosen in accordance with the known chemical affinity or properties of the particular ore to be operated upon. Thus, to take the instance of rich sulphates or sulphurets, I make a mixture of 1 part of common resin and 4 or 8 parts of coal tar, the use of the greater number than 4 parts of coal tar being necessary when the same is not highly bituminous.

Or, my agent is prepared thus:—1 part, by weight, of oily or fatty matter to from 4 to 8 parts of bituminous, resinous, or waxy matter; the difference between 4 and 8 parts being regulated by the character of the ore; ores containing much lime, or forms of lime, requiring the less number of these parts. This last-mentioned form of "agent" is adapted for all ores, except sulphates and sulphurets, or other sulphur-bearing ores.

In preparing my agent I prefer to use such bituminous and resinous substances and oleaginous, fatty, or waxy matter as may be soluble in alkali. Or, instead of the above, I form my agent of one part of coal tar to 2 parts of india-rubber or gutta percha; but when this agent is applied to the ore, I require to add water heated to 100 degrees of Fahrenheit's thermometer at least, instead of cold water, which answers for the other forms of my agent, though I prefer warm water in all cases.

Having thus prepared the agent in accordance with the character of the ore about to be treated, I apply it to the finely-divided ore as aforesaid by mixing the ore and agent together in a "mixing machine, that is, in an ordinary brickmaker's pug mill, or mortar mixer, or in any other apparatus that will effect the due mechanical admixture of the "agent" and the ore; which being done, I add as circumstances may require, either hot, warm, or cold water sufficient to well cover the whole, as herein-before referred to. Whereupon the agitation being still kept up, the agent acts upon the metal, and gradually effects the separation of the metal from the earthy or non-metallic matters of the ore or matrix, or ore and matrix, the earthy matter sinking to the bottom of the water, and the metal being retained by the agent I might here observe that where I speak of ore only, ore or matrix, or ore and matrix, should be understood.

To remove the agent from the metal, I put the agent and metal still in union in a vessel containing an alkaline solution, for instance, a strong solution of caustic soda in water, and in a short time the metal is precipitated to the bottom, and may be removed

With regard to the agent having the india-rubber or gutta percha, or both,

in its composition, I may be that it will be found particularly useful for gold-bearing, quartz, or siliceous ores.

The alkali and agent combined being a saponaceous matter, may be sold to soap makers and others as a commercial product; or this saponaceous solution may be used for the next operation, and so on, and then used for soap. Where the refuse is silica, it will be found available for commercial uses, being in fine powder.

(III.) Having now described the nature of the said Invention, and in what manner the same is to be performed, I declare that I claim the Invention of improvements in obtaining metals from their ores and matrices effected by the use of the substances described in the outset (marked I.) of this my Specification, in the manner herein-before set forth.

In witness whereof, I, the said William Haynes, have hereunto set my hand and seal, this 23rd day of August, in the year of our Lord One thousand eight hundred and sixty.

WILLIAM HAYNES. (L.S.)

Signed and sealed in my presence,

F. W. Campin,

Patent Agent, 156, Strand.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.

[Wt. 25-50 10/1907.]

N° 840 A.D. 1889

Date of Application, 16th Jan., 1889
Complete Specification Left, 12th Oct., 1889—Accepted, 23rd Nov., 1889

PROVISIONAL SPECIFICATION

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We, SAMUEL BAGSTER BOULTON, THOMAS BURT HAYWOOD, and HAROLD EDWIN BOULTON, trading under the firm of Burt, Boulton, and Haywood, of 64 Cannon Street, in the City of London, Manufacturers, and EDMOND RICH GABBETT, of Old Charlton, Kent, Civil Engineer, do hereby declare the nature of this invention to be as follows:—

According to this invention we effect the mixing or incorporation of liquids or semi liquids or the circulation of a liquid within a cauldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or *vice versâ*, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing or circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention; thus according to one arrangement we employ a conical, conoidal, paraboloidal or hemispherical shell immersed in a vertical position in the liquid and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required.

This shell is fixed by suitable arms to a central shaft carried in bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well known manner upon such body of liquid, causing it to rise up on the inner walls of the shell and to flow over the upper edge thereof, into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top. In place of only a single shell two or more concentric shells may be employed so as to cause a body of liquid to ascend the sides of each shell by centrifugal action, or the body of ascending liquid can be confined within an annular space formed between two concentrical shells, the inner one of which has no opening at the lower end.

When the upper end of the shell is immersed more or less below the level of the liquid, the central part of the upper opening thereof may be covered in by a shield so as to prevent the pressure of the column of liquid above the shell from interfering with the centrifugal action. In order to prevent slip between the inner surface of the shell and the liquid in contact therewith, the shell may be provided with internal longitudinal ribs or vanes.

According to another modification the shell is constructed with the lower end of more or less cylindrical tubular form, while the upper end is widened out to a trumpet-mouth shape, and the central part of this may also be more or less enclosed so that the centrifugal action in ejecting the liquid from the annular orifice thus formed will cause the liquid to be drawn up by the suction produced. Or the entire shell may be of a trumpet mouth shape, and it may be provided with an inner shell as above described with reference to the conical form.

Or, again, the upper end may be formed into two or more hollow horizontal arms communicating at the centre with the vertical tubular part, so that the liquid in being

ejected by centrifugal action from the hollow arms will produce a suction in the vertical tube.

According to another modification, instead of employing a continuous shell a number of separate tubular or trough shaped channels may be employed, receding from the central axis as they proceed upward, so that the liquid entering their lower ends is caused to ascend in them by centrifugal action, and flows out at the upper ends.

In all the above described constructions the reverse action may be obtained, that is to say, the liquid may be made to flow downwards through the apparatus by inverting the position of the latter.

In cases where it is preferred to suspend the shaft of the apparatus from bearings above the cauldron or tank, the downward pressure on the bearings due to the weight of the shell may be reduced by making the latter more or less buoyant either by forming it hollow with closed air spaces, or by combining therewith a float of any suitable construction.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Dated this 16th day of January 1889.

ABEL & IMRAY,
Agents for the Applicants.

COMPLETE SPECIFICATION.

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We Samuel Bagster Boulton, Thomas Burt Haywood, and Harold Edwin Boulton trading under the firm of Burt Boulton and Hayward of 64 Cannon Street in the City of London Manufacturers and Edmond Rich Gabbett of Old Charlton Kent, Civil Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

According to this invention we effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a cauldron or tank, by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top or *vice versâ*, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus affecting the mixing or circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention, thus according to one arrangement we employ a shell of a conical, conoidal, paraboloidal, hemispherical or trumpet mouthed shape fitted if necessary with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it and consequently to the body of liquid situated within it, the centrifugal force will act in the well known manner upon such body of liquid causing it to rise up on the inner wall of the shell and to flow over the upper edge then into the body of

liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

Holes or openings may be made in the shell or tubes at various heights to assist the distribution of the inner column of liquid or semi liquid, through the outer body or the shell may have reciprocating motion vertical or horizontal given to it or it may be made to travel round a centre for the same purpose.

Fig. 1 of the accompanying drawings shews a vertical section of one form of the above described apparatus, and Fig. 2 shews a plan.

A is a conical shell having interval ribs A^1 and mounted on a shaft B by which it is suspended within the vessel or tank C containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing box E on the cover of the vessel C.

Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing such as indicated at F then the body of liquid within the shell being carried round with the same by means of the ribs A^1, the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof while at the same time the pressure of the surrounding column of liquid in the vessel C, will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus a continuous circulation and consequent mixing of the liquid will be effected as indicated by the arrows.

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A, the vessel may be provided with projecting ribs C^1 as shewn, this is however not absolutely necessary and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular instead of circular as shewn, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving shaft or arranged in a row. Also instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving pullies carrying respectively an open and a crossed strap which are shifted alternately on to a loose pulley, as is well understood.

The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A so that the centrifugal action will cause the liquid within it to travel in a downward direction.

The shell A may also, if desired have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts.

This might be effected by connecting the lower part of the shaft B carrying the shell to the upper part running in fixed bearings by a universal joint, and imparting the described motion to and fro thereto by a crank. cam or excentric and connecting rod or by other suitable means.

The shell A may be made to extend above the level of the liquid, instead of being entirely immersed as indicated.

Figs. 3 to 10 shew diagram sections of various other forms which may be adopted for the revolving shell. Fig. 3 shews a paraboloidal shape, Fig. 4 a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shews an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action or there may be only two concentric shells as at Fig. 6 forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level, the arrangement shewn at Fig. 7 may be adopted in which the top of the shell A is covered by a shield A^1 leaving a narrow annular orifice at *a* for the issue of the liquid. By this means the

pressure of the column of liquid which would otherwise exist in the centre of the shell, is prevented from interfering with the centrifugal action. Fig. 8 shews a construction in which the lower part of the shell is made cylindrical while the upper part is made trumpet mouthed, the centrifugal action being in this case confined to the upper part or the entire shell might be made of a trumpet mouth shape.

Fig. 9 shews a construction with the lower part A more or less cylindrical and terminating at top in two or more tubular arms A' which may be either radial or curved. Fig. 10 shews a construction in which instead of employing a continuous shell two or more separate curved or inclined tubular or trough shaped channels A A are used, open at the upper and lower ends so that in revolving the liquid will be caused by the centrifugal action to rise in the tubes or troughs and be discharged at the upper ends in the same way as with the above described shells

Such tubes or channels may also be made with a helical curvature relatively to the axis of rotation so as to assist in producing the upward or downward motion of the liquid.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air tight chamber connected to the shell or shaft; thus for instance the shield A' shown in Fig. 7 being made hollow will by its flotation partly carry the weight of the shell &c. or in the of Fig. 6 if the inner vessel is covered and rendered air tight, the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing as described yet it will be evident that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Having now particularly described and ascertained the nature of this invention and in what manner the same is to be performed we declare that what we claim is:—

1. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of a vessel shell or tube or combination of vessels shells or tubes partly or wholly immersed in the liquid and having its or their upper and lower ends open, such vessel shell or tube being so formed as when rotated upon its vertical axis it will cause the liquid to rise or descend in the same by centrifugal action and to be discharged at the upper or lower end substantially as herein described

2. In apparatus for mixing incorporating or effecting the circulation of liquids, and semi liquids, the combination with the tank or cauldron C of a shell A of conical conoidal or equivalent shape with internal ribs or projections A' and carried by a vertical axis B driven by suitable gearing so as to cause the liquid in the tank or cauldron to ascend in the shell by centrifugal action and to be discharged into the tank at the upper end while at the same time fresh liquid is made to enter at the lower end, substantially as herein described with reference to Figs. 1 and 2 of the accompanying Drawings.

3. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of a tubular shell A with arms A' carried by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal action of the arms, A' the liquid is drawn up through the tubular shell A and expelled through the arms A' substantially as described with reference to Fig. 9.

4. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of tubular or trough shaped arms A curved by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal

action of the arms the liquid is caused to rise through them and to be ejected through the upper ends thereof, substantially as herein described with reference to Fig. 10.

Dated this 11th day of October 1889.

ABEL & IMRAY,
Agents for the Applicants.

London: Printed for Her Majesty's Stationery Office, by Darling & Son, Ltd.—P 10793-50-9/94-G 2170

(2nd Edition)

SHEET 1.

Fig. 1.

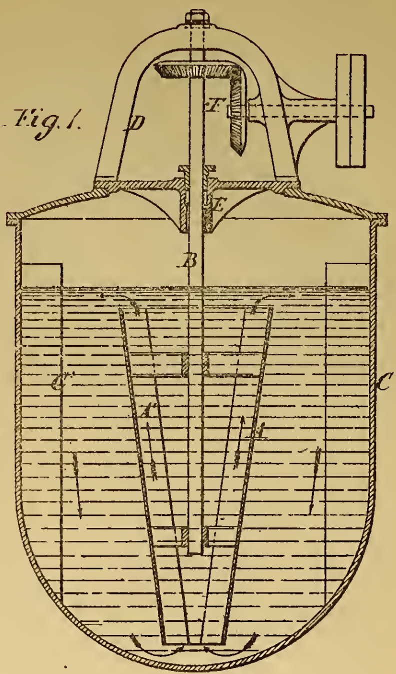
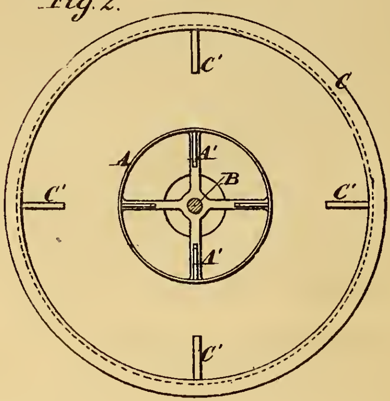
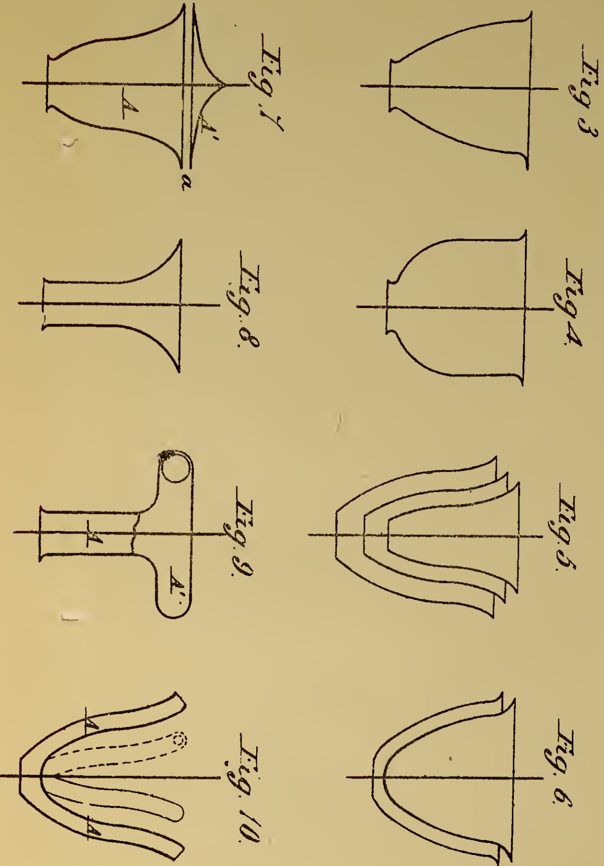


Fig. 2.



SHEET 2



(This Drawing is a reproduction of the Original on a reduced scale)

London. Printed by [illegible] and Son Ld.

[Second Edition.]

N° 7803 A.D. 1905

Date of Application, 12th Apr., 1905
Complete Specification Left, 3rd June, 1905—Accepted, 18th Jan., 1906

PROVISIONAL SPECIFICATION.

"Improvements in or relating to Ore Concentration"

We, HENRY LIVINGSTONE SULMAN, Metallurgist, of 44 London Wall, HUGH FITZALIS KIRKPATRICK PICARD, Metallurgist, of 44 London Wall, and JOHN BALLOT, Merchant, of 62 London Wall, all of the City of London, do hereby declare the nature of this invention to be as follows—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 18589 of 1903 granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the Specification of British Patent No. 17109 of 1903 granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a small fraction of 1% on the ore, granulation ceases to take place and on vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverisation of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a

very small proportion of oleic acid (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is agitated in a cone mixer or the like, as in the processes previously cited, for about $2\frac{1}{2}$ to 10 minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining or otherwise and is caused to subside; the coated metalliferous matter is separated from the liquid and treated with an alkali which removes the oleic acid in the form of a soap.

If desired, the oleic acid used in the first instance may be produced *in situ* in the pulp by decomposing a dilute soap solution with mineral acid as described in the British Patent No. 17109 of 1903 cited above.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of an air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Patent Application No. 29374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

Dated this 12th day of April, 1905.

BOULT, WADE & KILBURN,
Agents for the Applicants.

COMPLETE SPECIFICATION.

Improvements in or relating to Ore Concentration.

We, HENRY LIVINGSTONE SULMAN, Metallurgist, of 44, London Wall, HUGH FITZALIS KIRKPATRICK PICARD, Metallurgist, of 44, London Wall, and JOHN BALLOT, Merchant, of 62, London Wall, all of the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue

In the process described in the previous British Patent No. 18589 of 1903.

granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the previous British Patent No. 17109 of 1903, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a fraction of 1% on the ore, granulation ceases to take place and after vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverisation of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue, consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a very small proportion of oleic acid or petrol, or other suitable oil (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid petrol oil *etc.* has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid namely the blende and galena. The minimum amount of oleic acid or petrol *etc.* which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise; after subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali which removes the oleic acid petrol oil *etc.* in the form of a solution of soap.

Improvements in or relating to Ore Concentration.

If desired, the oleic acid used in the first instance may be produced *in situ* in the pulp by decomposing a dilute soap solution with mineral acid as described in the British Patent No. 17109 of 1903 cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth, may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron or other salts are present in small quantity during the production, or on the breaking down of the froth with alkali; such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Application for Patent No. 29374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

The accompanying drawing is a diagram of one form of apparatus suitable for carrying this invention into practice.

A mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E controlled by a tap E^1 delivers circuit water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F^1. The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus.

In passing from the frothing apparatus A to the spitzkasten (say between O and K^1) the pulp may if desired be run in a thin layer over a smooth slightly inclined plane and may be submitted to the action of a series of air jets in order to increase the amount of floating metalliferous matter to a maximum.

The froth separating apparatus comprises several (say three) pointed boxes J^1, J^2, J^3 which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K^1 and spreads out to a wide outlet K^2. The pointed boxes J^1, J^2, J^3 have full-way cocks L^1, L^2, L^3, at the bottom leading to swan-neck discharge pipes M^1, M^2, M^3. An up-current of water may be led in at the bottom of each box through a tap N^1, N^2, N^3.

The boxes are all filled with circuit water; the pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K^1. The heavy sands and coarser particles of mineral sink into the first box J^1 from which they are led to a shaking table, convex buddle, or the like to be treated as above described. The middlings or medium sands fall into the box J^2 and if they contain any mineral, may be removed for further treatment by agitation. The up-current of water from the taps N^1 N^2 prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J^3 from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K^2 into a launder P and thence to a filter Q where the metalliferous matter is removed from the circuit water which is returned to the vessel A by a pump R. The circuit water may be brought to the proper temperature by passing it through a heater S having a burner S^1 before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows:—The products suspended in circuit liquor are removed from the spitzkasten and placed

in a vessel in which they are submitted to an additional pressure of air or other gas of from, say, 1 to 2 atmospheres, or over. On relief of such pressure the bubbles of air, or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. The process of concentrating ores in which finely powdered ore suspended in acidified water is mixed with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, and agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation.

2. In the process of concentrating ores covered by Claim 1, warming the pulp (say to 30—40° C) to facilitate the oiling of the metalliferous matter.

3. The process of concentrating ores which consists in agitating the finely powdered ore suspended in acidified water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the slime mineral forms a froth separating the froth by flotation and separating the coarser mineral from the gangue by exposing them alternately to air and water on a shaking table or the like.

4. The process of concentrating ores which consists in agitating the powdered ore suspended in the water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the oil-coated slime mineral forms a froth, distributing the mixture on the surface of a current of water running over spitzkasten so that the coarser minerals and sands the finer sands and gangue slimes successively deposit out while the froth is floated away by the current and separated by filtration.

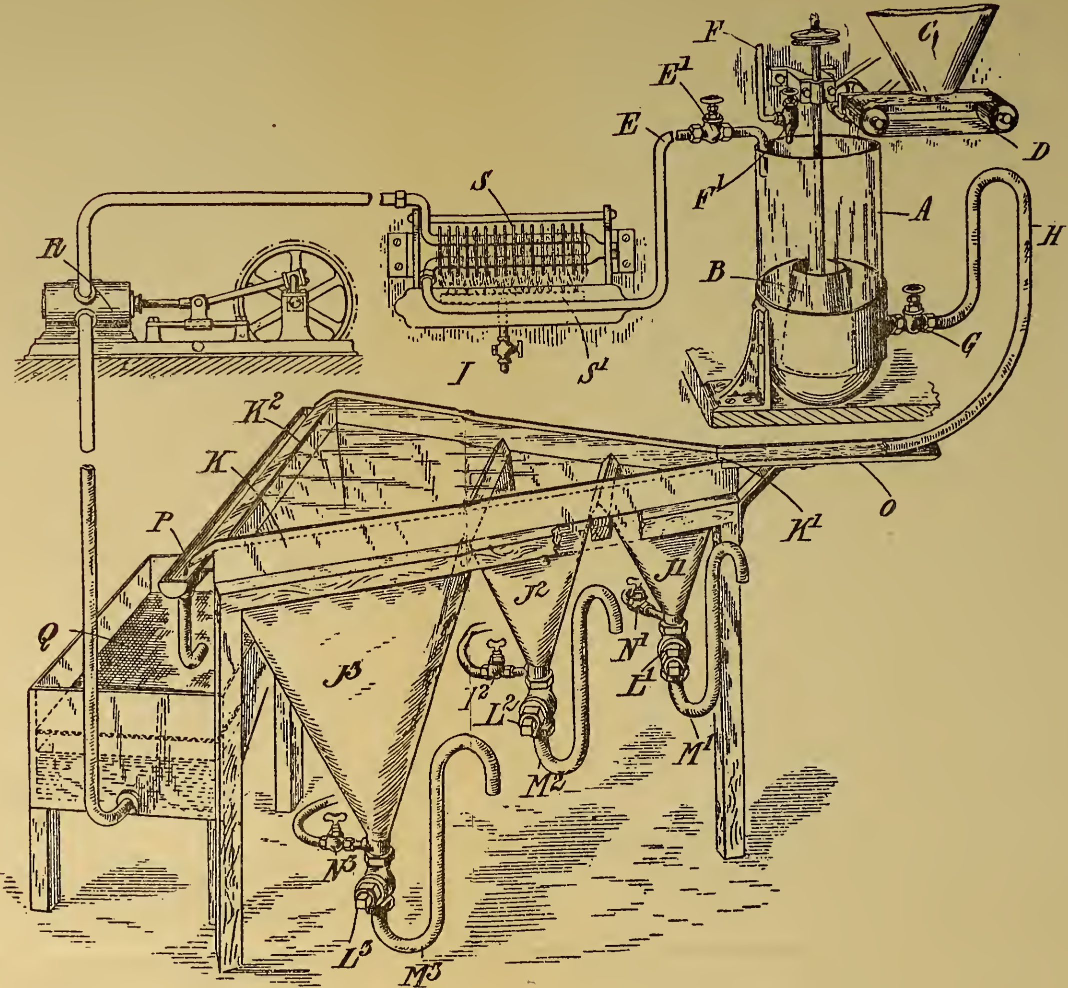
Dated this 2nd day of June, 1905.

HENRY LIVINGSTONE SULMAN,
HUGH FITZALIS KIRKPATRICK PICARD
JOHN BALLOT

Boult, Wade & Kilburn,
Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[G. 9181—125—8/1906]

(2nd Edition)



[This Drawing is a full-size reproduction of the Original.]

N° 17,328 A.D. 1906

Date of Application, 1st Aug., 1906—Accepted, 25th Oct., 1906

COMPLETE SPECIFICATION.

"Improvements in or relating to Ore Concentration."

(A communication from GEORGE ALBERT CHAPMAN, Metallurgist, of Central Mine, Broken Hill, State of New South Wales, Commonwealth of Australia).

We, MINERALS SEPARATION LIMITED, of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 7803 of 1905, granted to Sulman, Picard & Ballot, finely powdered ore, suspended in acidified water, is mixed with a small proportion of an oily substance, such as oleic acid, amounting to a fraction of 1% on the ore, and the whole is agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation. In the arrangement particularly described for carrying the invention into effect, the ore, oil and acidified water were all mixed together in one agitating vessel and any number of such vessels could be employed in series.

In carrying this process into practice where a number of agitating vessels are used in series, it has now been found that particularly effective results can be obtained if the ore is first agitated with acidified water, say in the first vessel and if the oil is subsequently added, say to a second or following vessel.

Where it is desired to heat the pulp to increase the formation of froth, conveniently the heating can take place after the addition of the oil, for example the pulp may be raised to a suitable temperature when it reaches the third or last agitating vessel of the series.

By thus arranging the sequence of operations, it is found that while the acid strength of the liquor in the first vessel may be say 0·225% acid, the strength in the second vessel is then about 0·05% acid, while in the remaining agitating vessels, in the Spitzkasten feed tanks and other vessels, the acid may be practically or entirely neutralised so that the liquor in circuit as a whole is neutral except at the outset when the ore is introduced.

Having now particularly described and ascertained the nature of the said invention, as communicated to us by our foreign correspondent, and in what manner the same is to be performed, we declare that what we claim is:—

1. The improvement upon the process described in British Patent No. 7803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel and subsequently adding the necessary small proportion of oil or the like in a second or following agitating vessel, substantially as described.

2. The improvement upon the process described in British Patent No. .803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel, subsequently adding the necessary small proportion of oil or the like, say in a second or following agitating vessel, and thereafter heating the mixture in another vessel, substantially as described.

3. The complete improvement upon the process described in British Patent No. 7803 of 1905, substantially as described.

Dated this 1st day of August 1906.

BOULT, WADE & TENNANT
Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 25—125/1/1908]

N° 23,870 A.D. 1910

Date of Application, 14th Oct., 1910

Complete Specification Left, 6th Apr., 1911—Accepted, 14th Nov., 1911

PROVISIONAL SPECIFICATION.

Improvements in or relating to Ore Concentration.

(Partly communicated from Henry Lavers, Metallurgist, of Whittaker Street, Broken Hill, New South Wales)

We, Minerals Separation Limited, and Edward Hoit Nutter, Metallurgist & Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention to be as follows.—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides

It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus, according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addition of an oily substance

[*Price* 8*d.*]

such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners, jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes: but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of ore treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain constituents to float in the form of a froth or scum—it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 *etcetera*.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

Improvements in or relating to Ore Concentration.

The following are examples of applications of this invention:

In the case of an ore containing gangue and sulphides of copper and zinc. if the crushed ore is agitated with water containing a minute proportion of a frothing agent such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and a separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the previous Application No. 6896/1910 the formation of a froth can be effected under different conditions in the different agitators. The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore or product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another.

Dated this 14th day of October, 1910.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to Ore Concentration.

We, MINERALS SEPARATION LIMITED, and EDWARD HOIT NUTTER, Metallurgist and Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used.

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue. It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides.

Improvements in or relating to Ore Concentration.

It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another. This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addition of an oily substance such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes: but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of ore treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain

constituents to float in the form of a froth or scum—it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another.

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 *etcetera*.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

The following are examples of applications of this invention:—

In the case of an ore containing gangue and sulphides of copper and zinc, if the crushed ore is agitated with water containing a minute proportion of a frothing agent such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine-zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the previous Application No. 6896/1910 or in the concurrent Application No. 23,949/1910 the formation of a froth can be effected under different conditions in the different agitators The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore or product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another

Improvements in or relating to Ore Concentration.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, as communicated to us by our foreign correspondent, we declare that what we claim is:—

1. The herein described process of concentrating ores which consists in mixing the ore with water and with agents necessary to bring about the formation of a mineral bearing froth, agitating the pulp with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore or in an ordinary froth, removing the froth and retreating it under similar differentiating conditions.

2. The herein-described process of concentrating ores which consists in agitating the ore with water containing one mineral frothing agent so as to yield a certain froth containing a fraction of the floatable minerals and removing the froth, agitating the pulp again with the addition of another agent which results in the production of another froth containing a second fraction of the flotable mineral and so on, substantially as described.

3. The herein described process of concentrating ores which consists in agitating the ore pulp first with the addition merely of a mineral-frothing agent but without mineral acid and removing the froth agitating the remaining pulp again with the addition of mineral acid as well as the mineral-frothing agent, removing the froth and thereafter agitating the pulp again with the addition of an oily substance such as oleic acid and removing the froth, each of which froths may be re-treated under differentiating conditions.

4. The herein-described process for concentrating ores which consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately by a classifying apparatus to separate the constituents.

5. The complete process for concentrating ores substantially as described.

Dated this 6th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1911.

N° 23,949 A.D. 1910

Date of Application, 15th Oct., 1910

Complete Specification Left, 18th Apr., 1911—Accepted, 15th Nov., 1911

PROVISIONAL SPECIFICATION.

Improvements in or relating to Method and Apparatus for Ore Concentration.

We, Edward Hoit Nutter, Metallurgist and Mining Engineer, and Theodore Jesse Hoover, Metallurgist and Consulting Engineer, and Minerals Separation Limited, all of 62, London Wall, in the City of London, do hereby declare the nature of our invention to be as follows:—

This invention is for improvements in or relating to method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to these certain particles which are thereby caused to float, while other particles are not so floated. Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated. One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration.

In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

[*Price* 8*d*.]

Improvements in or relating to Method and Apparatus for Ore Concentration.

A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another. A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other collector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

The following is a description by way of example of one form of apparatus embodying this invention:—

Several mixing vessels are placed side by side on the same level. These may conveniently be vats separated by partitions. Each vessel is provided with a rotatable agitator or stirrer carried by a vertical spindle rotated at a high speed by any convenient means.

The first vessel is connected to the second, the second to the third, the third to the fourth and so on by passages and compartments outside the mixing vessels lying along one side of the mixing vessels or between them and on the same level with them. By this arrangement the pulp passes from the first vessel through the connecting passage or compartment to the second vessel and so on, and at the end of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911/1909 for example.

At each connecting passage or compartment there is a froth trap, that is to say, baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes before the bubbles reach the free air surface and have a chance to break. Thus, for example, a wall of each connecting passage may be formed by a partition the top or lip of which is below the level of the free air surface of the froth when the apparatus is working. The froth rises in the connecting passage and a roof or cover is provided to lead the froth over the lip or partition before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment and the bubbles which burst deposit the mineral in the trap compartment. The outer wall of the trap compartment may comprise a second lip higher than the first; and the more permanent froth will collect in the trap compartment and flow over the second lip into a launder and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink

back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunity of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed.

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation In the Patent Application No 23,870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions.

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different floatable constituents

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through which the froth passes away from the pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Dated this 15th day of October, 1910.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E C.,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to Method and Apparatus for Ore Concentration.

We, Edward Hoit Nutter, Metallurgist and Mining Engineer, and Theodore Jesse Hoover, Metallurgist and Consulting Engineer, and Minerals Separation Limited, all of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to a method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to these certain particles which are thereby caused to float, while other particles are not so floated. Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration.

Improvements in or relating to Method and Apparatus for Ore Concentration.

In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments. The mixing vessels may be connected together in pairs by orifices in the partitions between them, and the passages outside the vessels may be arranged to connect one vessel of each pair with the adjacent vessel of the next pair, a froth trap being placed at each passage.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other collector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

In the accompanying drawings which illustrate by way of example one form of apparatus embodying this invention,

Figure 1 is a front elevation partly in section,

Figure 2 is a transverse section, and

Figure 3 is a plan of the apparatus.

Several mixing vessels A are placed side by side on the same level Each vessel is provided with a rotatable agitator or stirrer A^1 carried by a vertical spindle A^2 rotated at a high speed by any convenient means. The first vessel

is connected with the second, the second to the third, the third to the fourth and so on by passages or compartments B between the mixing vessels and on the same level with them. By this arrangement the pulp passes from the first vessel A through the connecting passage or compartment B to the second vessel A and so on and at the end of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911 of 1909 for example.

At each connecting passage or compartment B there is a froth trap, that is to say baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes, before the bubbles reach the free air surface and have a chance to break. Thus, for example, the wall of each connecting passage B may be formed by a partition D the top or lip D¹ of which is below the level of the free air surface of the froth when the apparatus is working.

The froth rises in the connecting passage B and a roof or cover E is provided to lead the froth over the lip or partition D before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment F into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment F and the bubbles which burst deposit the mineral in the trap compartment. The outer wall G of the trap compartment may comprise a second lip G¹ higher than the first; and the more permanent froth will collect in the trap compartment F and flow over the second lip G¹ into a launder H and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level, throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunity of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation. In the Patent Application No 23.870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different flotable constituents.

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through which the froth passes away from the

pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like. The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach the liquid surface whereby the froth is collected and removed from the pulp.

2. A method of ore concentration by the formation of a mineral bearing froth which consists in causing the froth as it is formed to fall over a trap or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid the combination with two mixing vessels of a passage which conveys the ore pulp from one vessel to another and a froth conduit from the passage whereby the froth is led away and trapped substantially as described.

4. A practical form of apparatus of the kind described for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a number of mixing vessels substantially on the same level connected together in pairs by orifices in the partitions between them and passages outside the vessels connecting one vessel of each pair with the adjacent vessel of the next pair and a froth trap at each passage whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels.

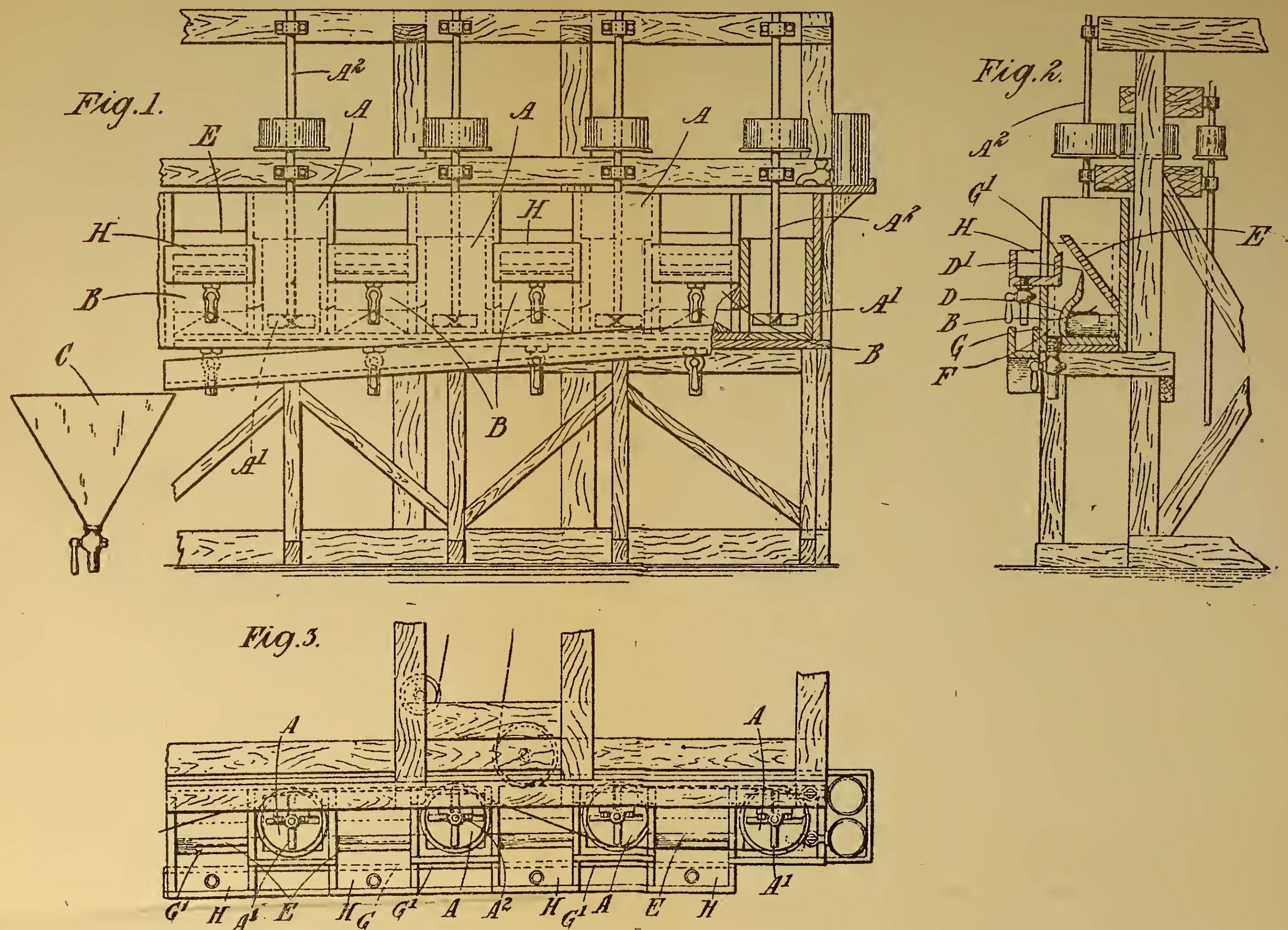
5. In an apparatus as covered in any of the preceding claims the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes into a launder or other collector.

Dated this 18th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1911.

(This Drawing is a reproduction of the Original on a reduced scale)



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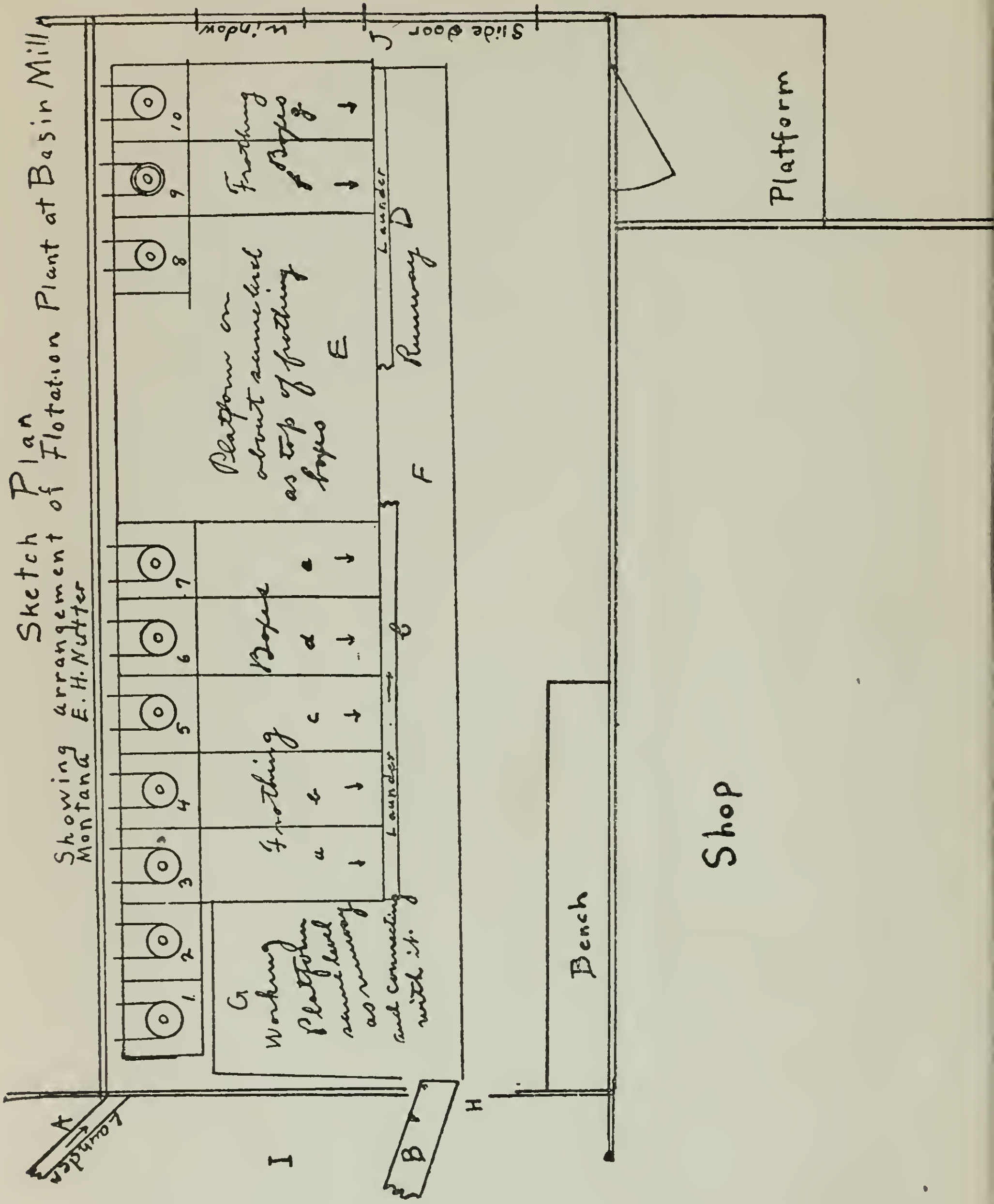
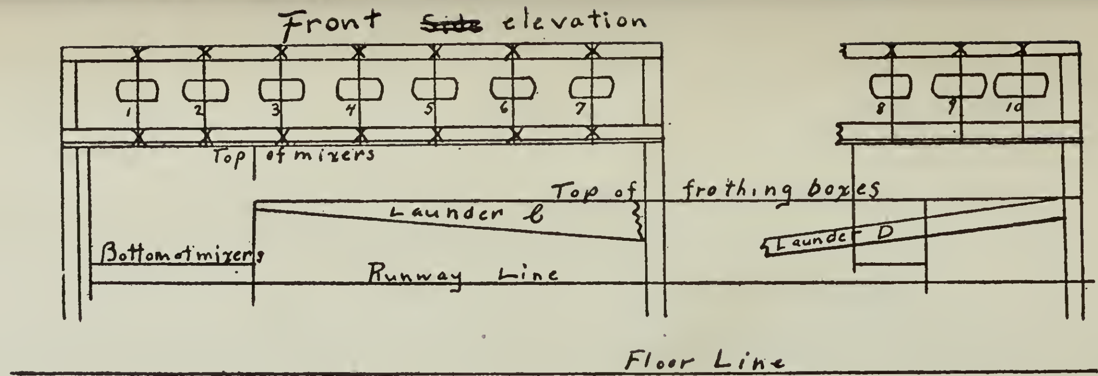
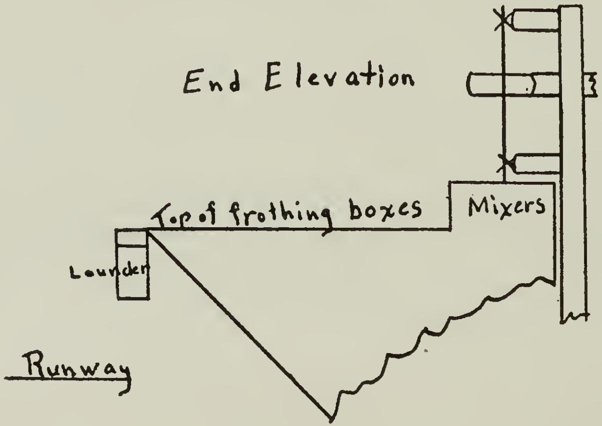
COMPLAINANTS' EXHIBIT, NUTTER DRAWING DEFENDANT'S PLANT (Sheet 1).



COMPLAINANTS' EXHIBIT, NUTTER DRAWING DEFENDANT'S PLANT (Sheet 2).



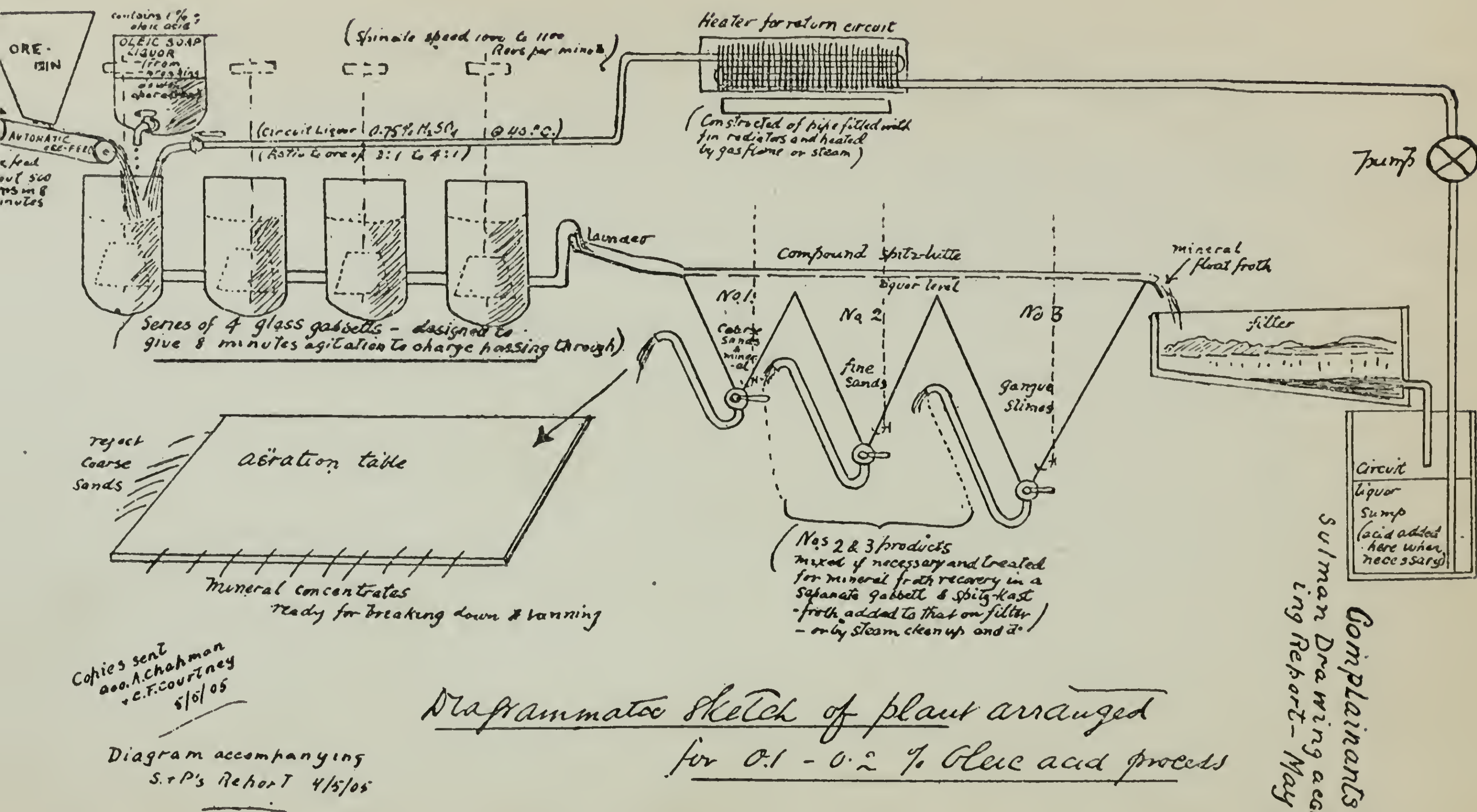


Sketches showing front and end elevations of flotation plant in Basin mill Montana. E.H. Nutter

Figures and letters have the same reference value in all sketches

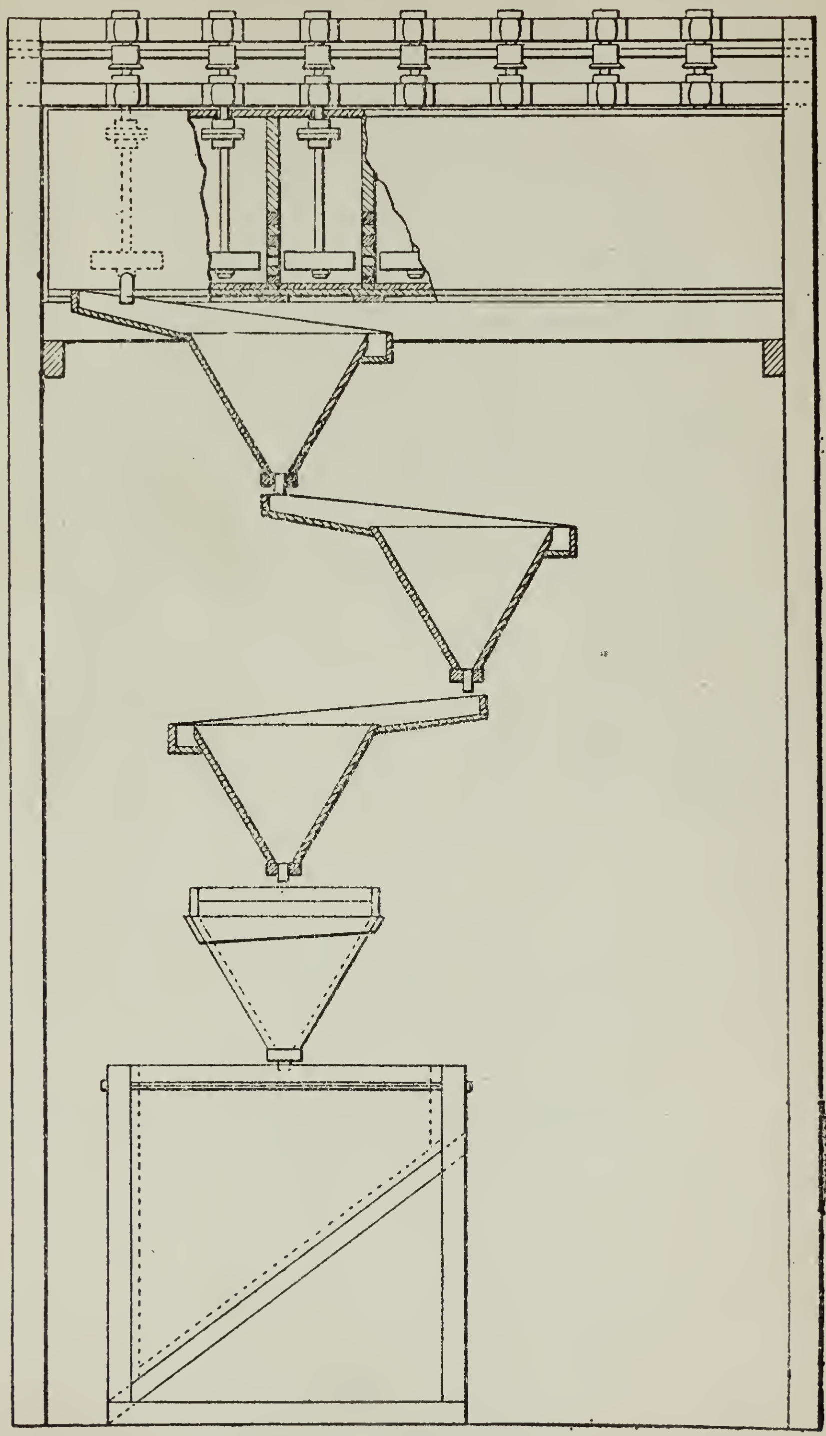
Broken lines indicate the extent of my observations. Framework carrying agitator bearings may be different than shown as I did not observe it closely.

Crosses indicate shaft bearings



Complainants' Exhibit Sulman Drawing accompanying Report - May 3, 1905.

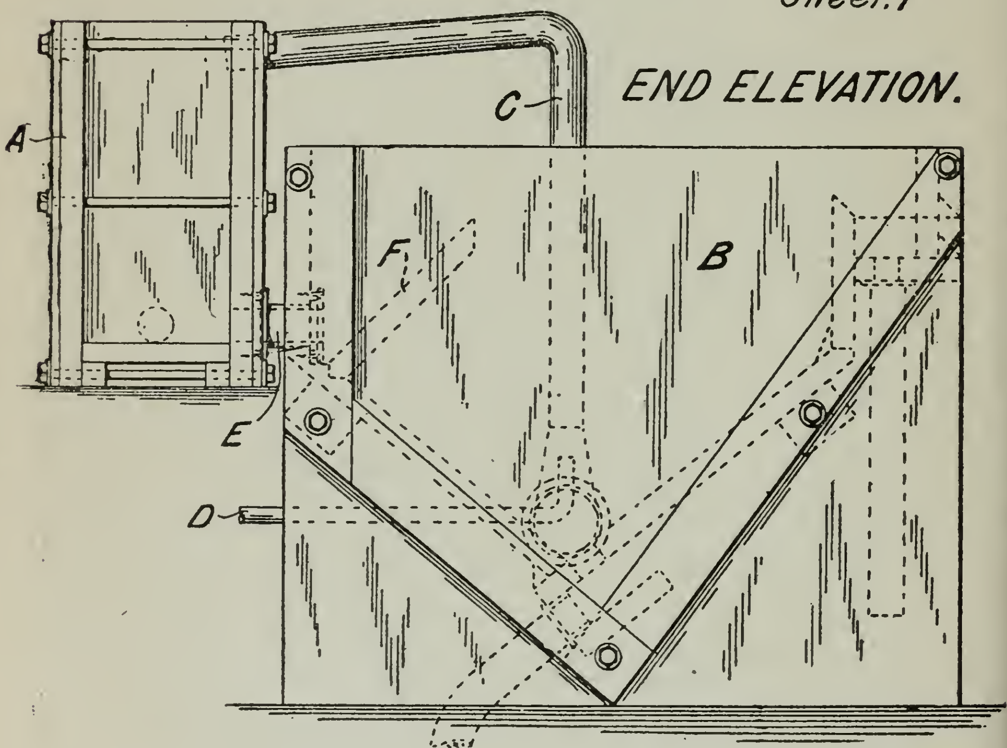
COMPLAINANTS EXHIBIT DRAWING AUSTRALIAN MODEL PLANT



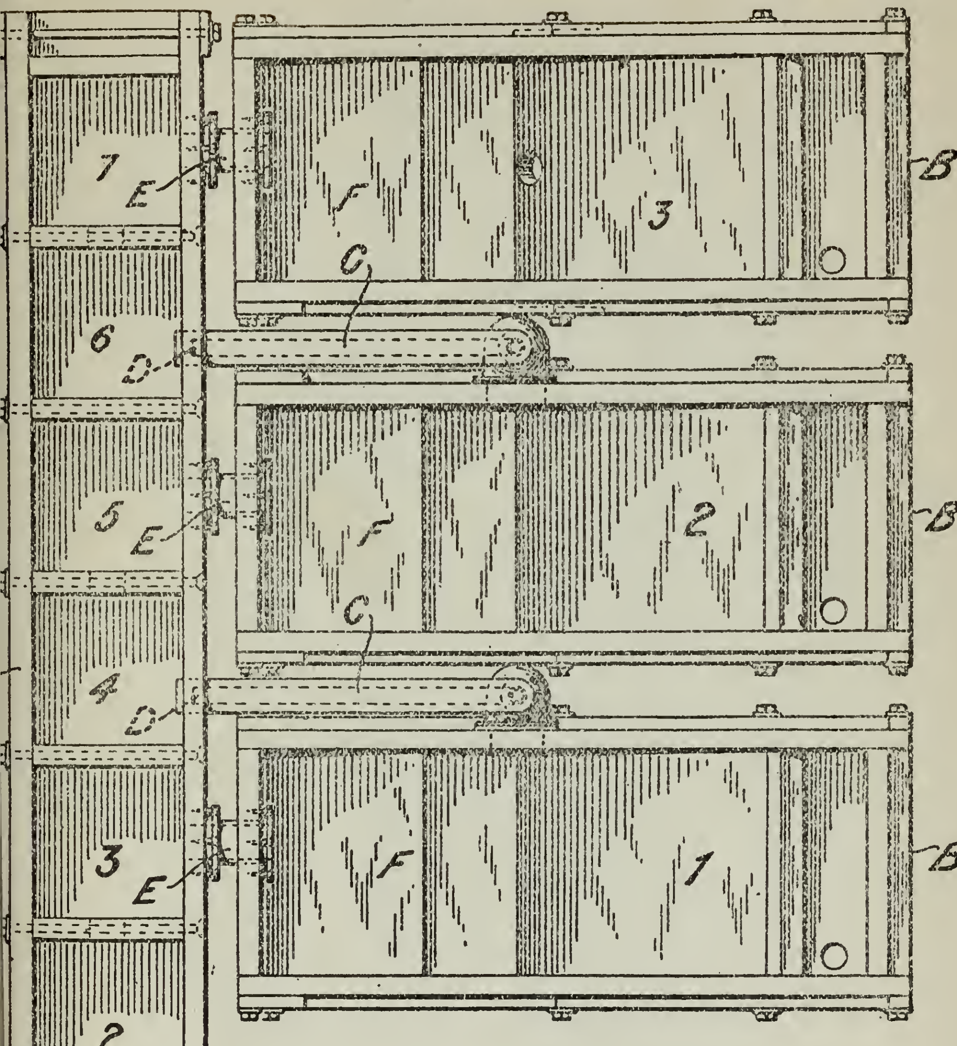
COMPLAINANTS EXHIBIT DRAWING OF
1909 AND 1910 AGITATION-FROTH PLANTS.
— THE EMU PLANT AND LAST —
CHARLOTTE STREET PLANT.

Sheet. 1

END ELEVATION.



PLAN. Sheet. 2.

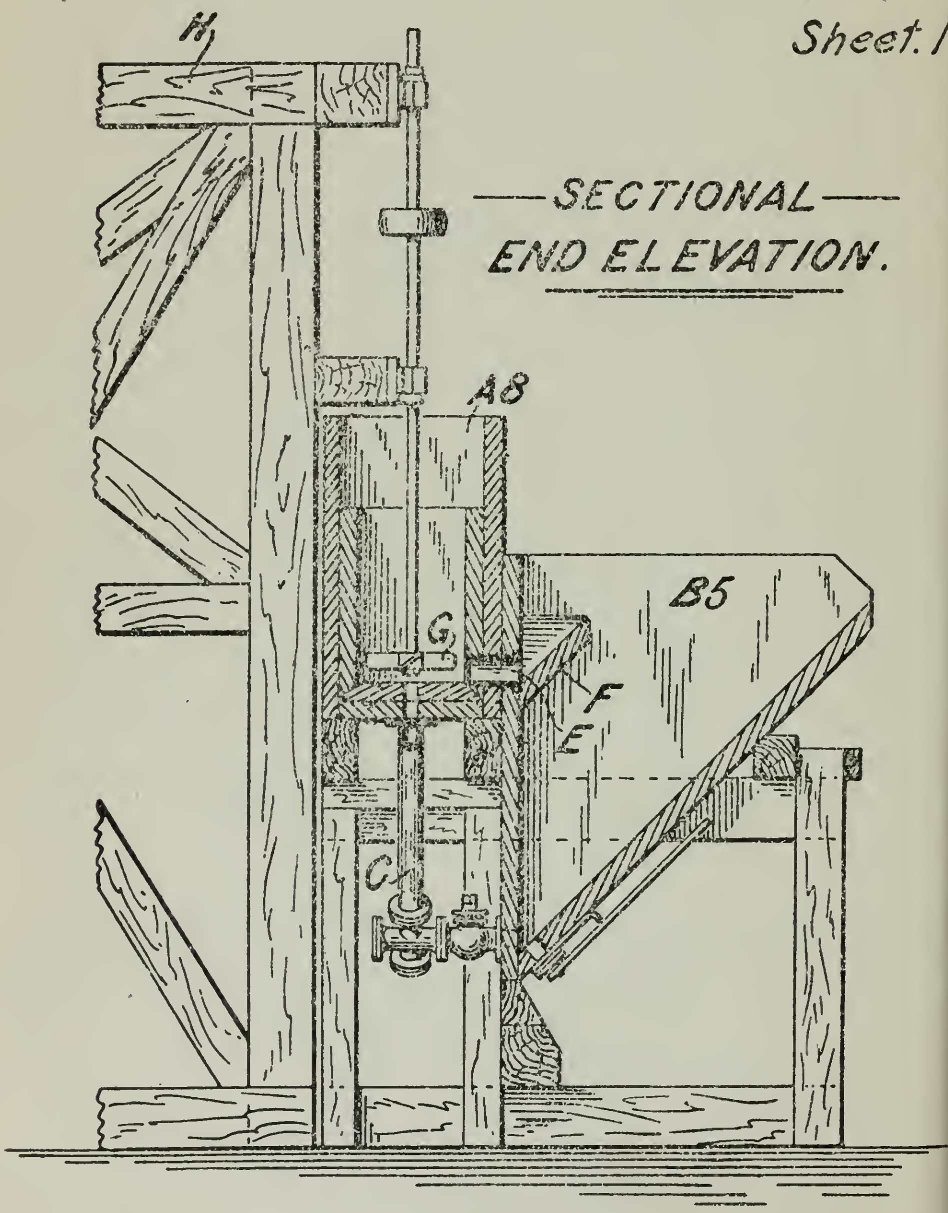


COMPLAINANTS EXHIBIT DRAWING OF —
1909 AND 1910, AGITATION-FROTH PLANTS.
— THE EMU PLANT AND LAST —
CHARLOTTE STREET PLANT.

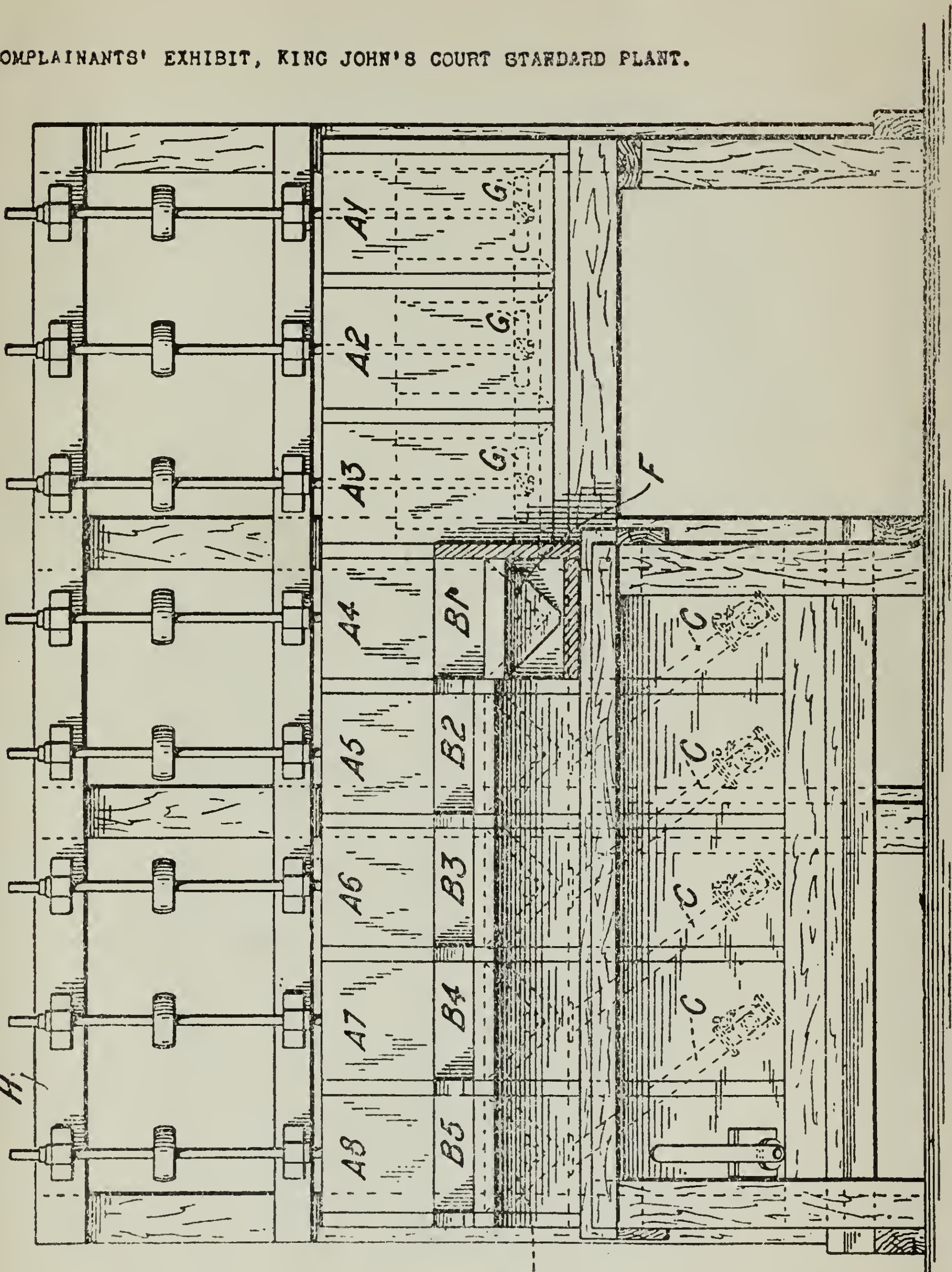
— COMPLAINANTS EXHIBIT —
KING JOHN'S COURT STANDARD PLANT.

Sheet. I.

—SECTIONAL—
END ELEVATION.



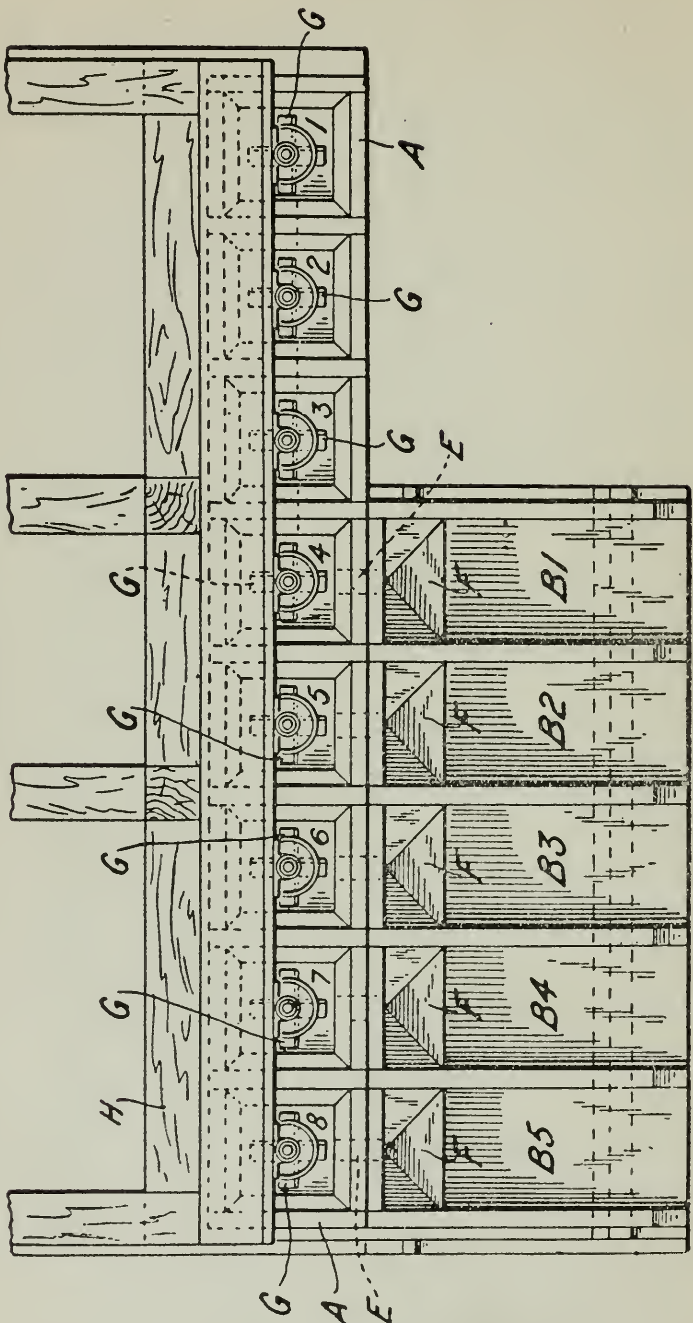
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.



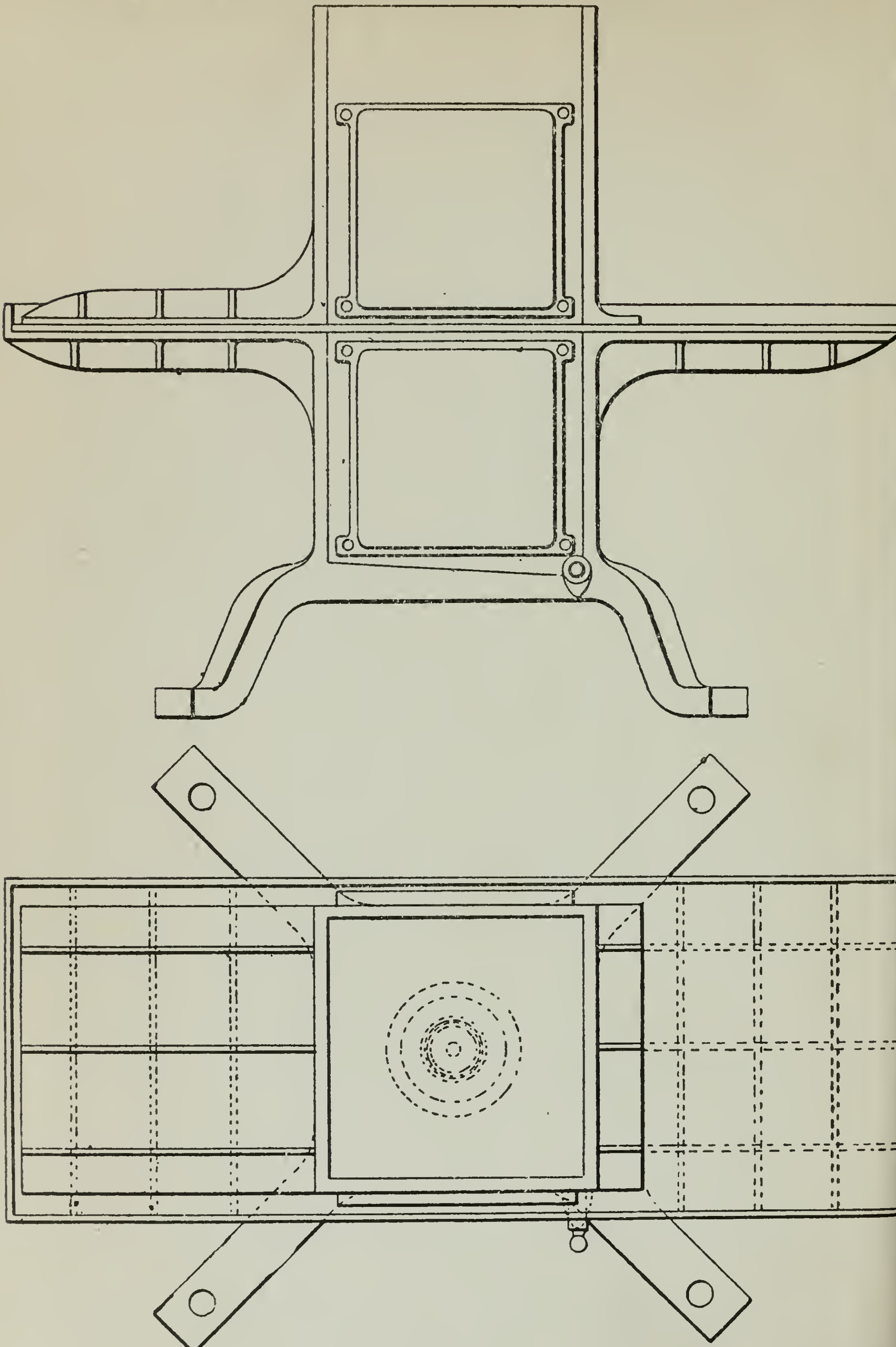
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.

Sheet. 3.

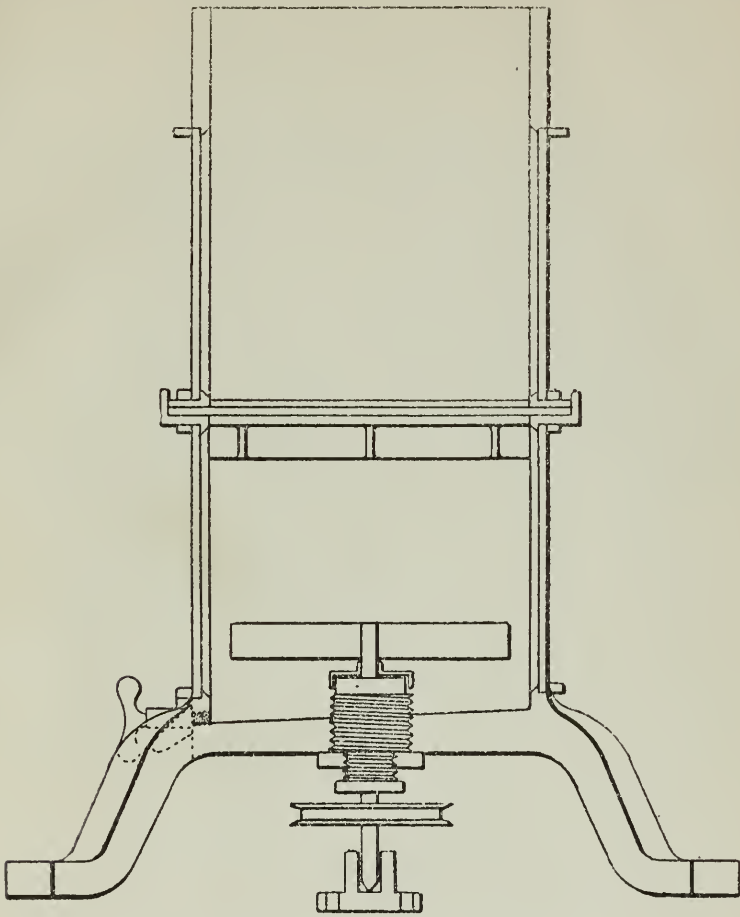
PLAN.



COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE

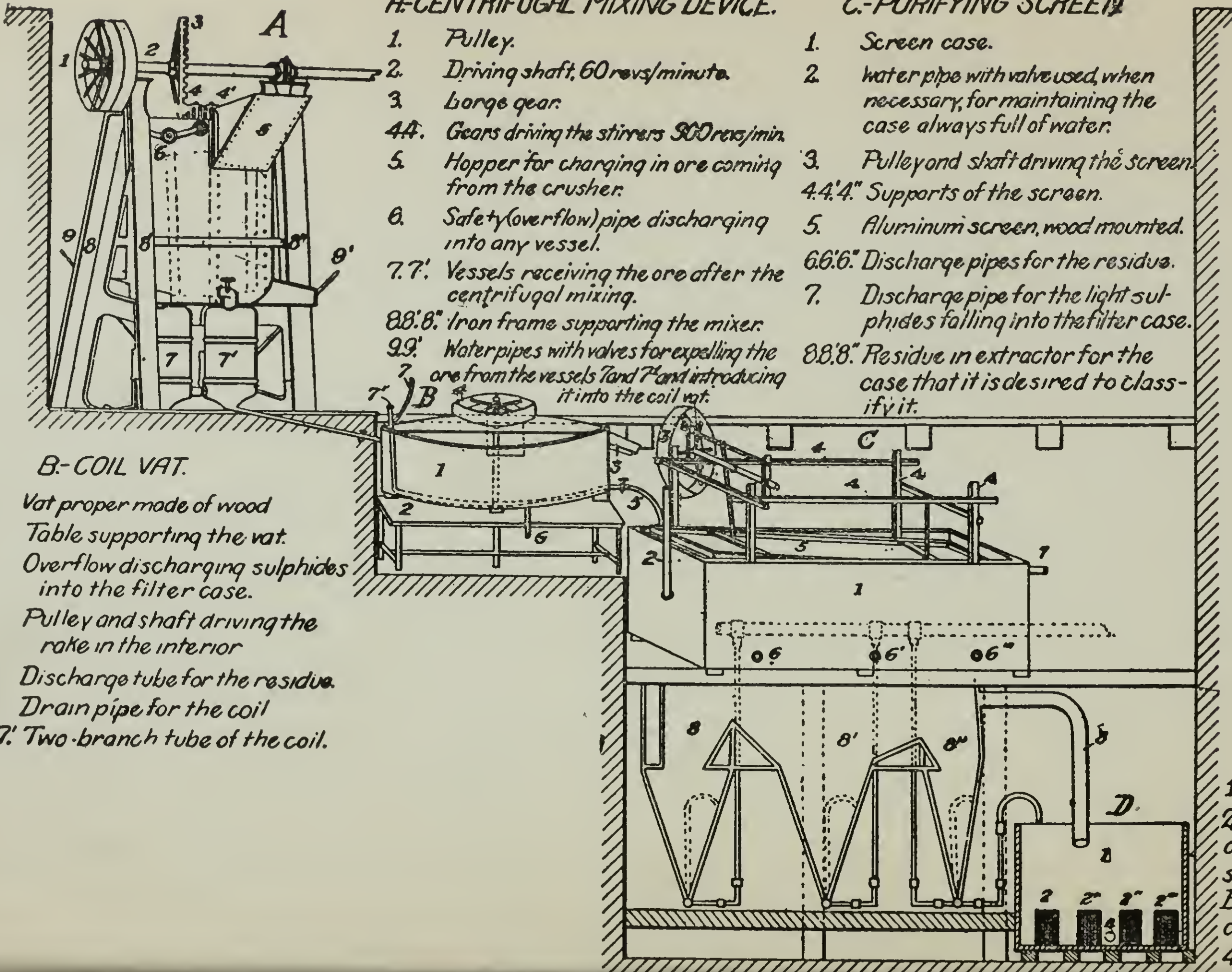


COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE.



MINERALS SEPARATION LIMITED.
62 London Wall
Drawing No 100
Date . ...

COMPLAINANTS' EXHIBIT FROMENT PLAN.



A-CENTRIFUGAL MIXING DEVICE.

1. Pulley.
2. Driving shaft, 60 revs/minute.
3. Large gear.
4.4'. Gears driving the stirrers 900 revs/min.
5. Hopper for charging in ore coming from the crusher.
6. Safety (overflow) pipe discharging into any vessel.
7.7'. Vessels receiving the ore after the centrifugal mixing.
8.8'.8". Iron frame supporting the mixer.
9.9'. Waterpipes with valves for expelling the ore from the vessels 7 and 7' and introducing it into the coil vat.

C.-PURIFYING SCREEN

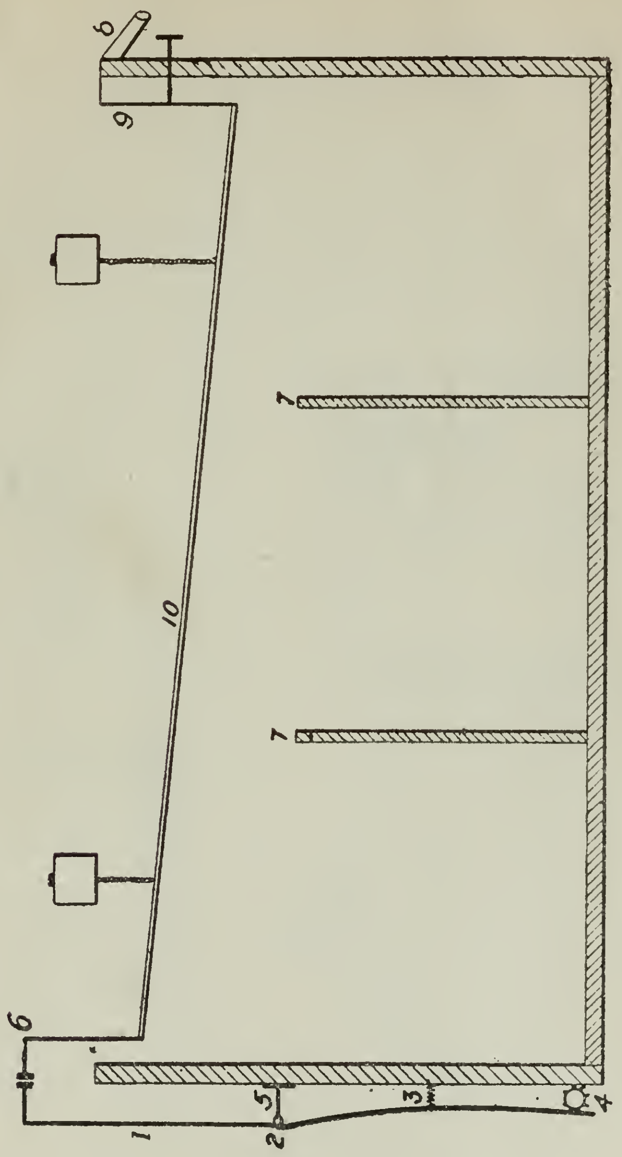
1. Screen case.
2. Water pipe with valve used, when necessary, for maintaining the case always full of water.
3. Pulley and shaft driving the screen.
4.4'.4". Supports of the screen.
5. Aluminum screen, wood mounted.
6.6'.6". Discharge pipes for the residue.
7. Discharge pipe for the light sulphides falling into the filter case.
8.8'.8". Residue in extractor for the case that it is desired to classify it.

B.-COIL VAT.

1 Vat proper made of wood
2 Table supporting the vat.
3 Overflow discharging sulphides into the filter case.
4 Pulley and shaft driving the rake in the interior
5. Discharge tube for the residue.
6. Drain pipe for the coil
7.7'. Two-branch tube of the coil.

D-FILTER CASE.

1. The case proper.
2.2'.2".2'". Canvas filters consisting of a wooden frame with canvas stretched on both sides. Between the two canvases is contained charcoal powder.
4. Emergency discharge pipe

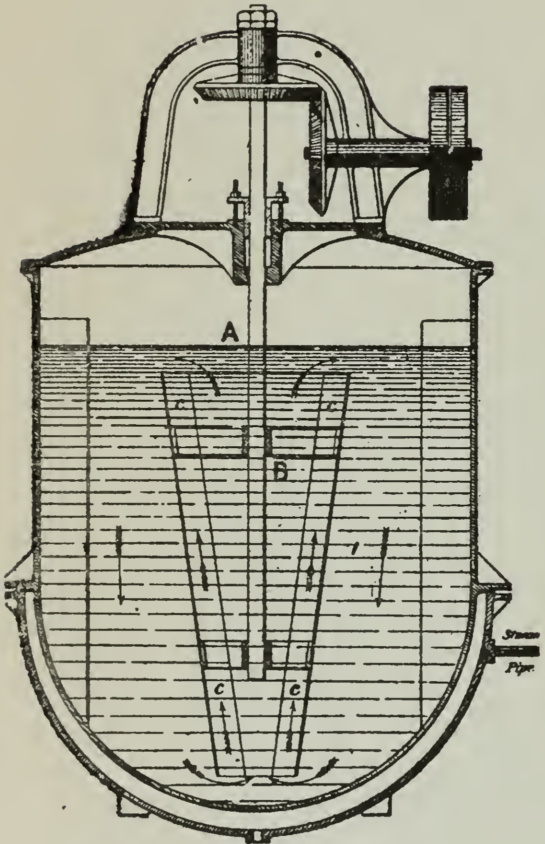


1. Iron Vibrator.
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.
6. Countershock mounted on the vat
7. Partitions.
8. Overflow.
9. Flexible iron stop.
10. Screen.

COMPLAINANT'S EXHIBIT-YOUNG FIRST CIRCULAR

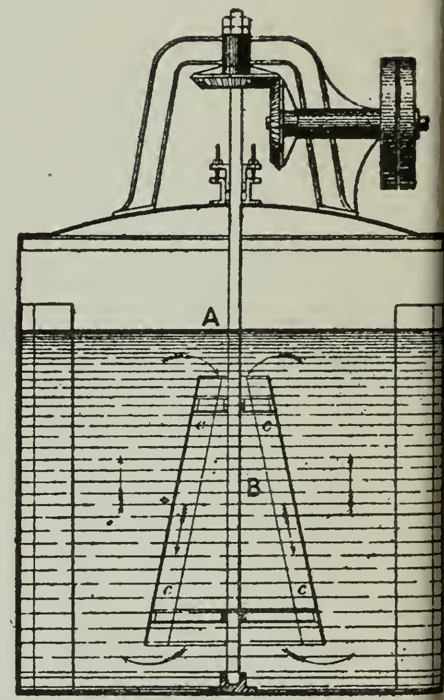
THE RAPID MIXER

Fig 1



Cast Iron Tank with Steam Jacket

Fig 2



Wrought Iron Tank Circular or Square

Burt, Boulton & Haywood & E R Gabbett's

——— Patent. ———

COMPLAINANT'S EXHIBIT - YOUNG FIRST CIRCULAR

The Rapid Mixer is suitable for mixing any description of liquids or semi-liquids, irrespective of their difference in specific gravity.

The acting principle is centrifugal force which operates on that portion of the contents of the vessel **A** which is enclosed by the revolving cone **B**, and is thus caused to rotate with the cone by the vanes or vertical baffle plates *c c*.

The material to be treated is thus caused to mount the inside of the cone as shewn in Figure 1, it then flows out over the top, and returns again at the bottom, and the whole contents are thus circulated and turned over with a violent mixing action.

The rapidity of this circulation is governed by the speed at which the cone is driven, but a very moderate rate is sufficient for all practical purposes.

In Figure 2 the cone is inverted and the reverse action to that described above takes place, the contents being drawn from the top and discharged at the bottom, the most suitable form depending on the composition of the materials to be treated.

The advantages claimed for the Rapid Mixer are :—

1. The thorough and complete manner in which the mixing operation is carried out on materials differing very considerably in specific gravity ; for example, if mercury and water are placed in the vessel as shewn in Figure 1, the former will be drawn up and distributed in a fine shower through the latter, although the difference in gravity in this case is as 1 to 13·59.

2. Simplicity of form.

3. No working parts need be in contact with the materials to be used.

4. The cone can be made of any material, even stoneware or glass, being thus applicable to the most corrosive liquids.

5. It can be adapted to any existing tank either round or square, and the cones can be used singly or in series.

6 The very small amount of power required in working.

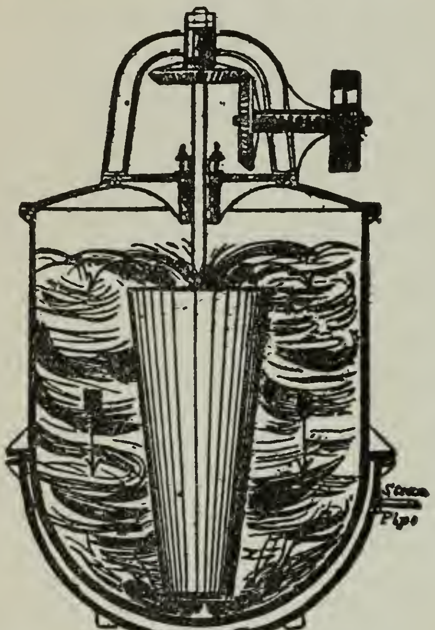
NOTE. The Rapid Mixer can be made of any size, and the form varied to suit special requirements, it is applicable to all forms of manufacture, where the intimate admixture of liquids or semi-liquids is required.

All information and estimates can be obtained from Messrs. H. Young & Co., Engineers, Eccleston Street, Pimlico, London, and the apparatus can be seen at work by appointment.

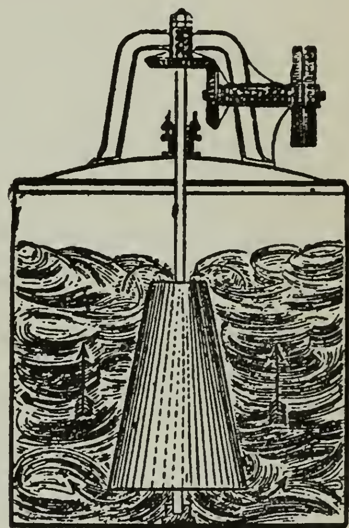
COMPLAINANT'S EXHIBIT-YOUNG ADVERTISEMENT "A"

THE RAPID MIXER.

BURT, BOULTON, & HAYWOOD and E. R. GABBETT'S PATENT.



Cast-Iron Tank with Steam Jacket



Wrought-Iron Tank, Circular or Square.

This Mixer is specially suited for all operations where the perfect Admixture of Liquids or Semi-Liquids is required, irrespective of their difference in Specific Gravity.

ADVANTAGES:—

In Action absolutely Perfect.
Simplicity in Construction, and easily adapted to any Tank.
No Working Parts need come in contact with Materials treated.
Wear and Tear practically Nil
Minimum Power in Driving.

Can be made in any Material, even Glass or Stoneware, and is therefore applicable to the most Corrosive Substances.

All Information and Estimates can be obtained from

MESSRS. H. YOUNG & CO., ECCLESTON IRONWORKS, PIMLICO, LONDON, S.W.

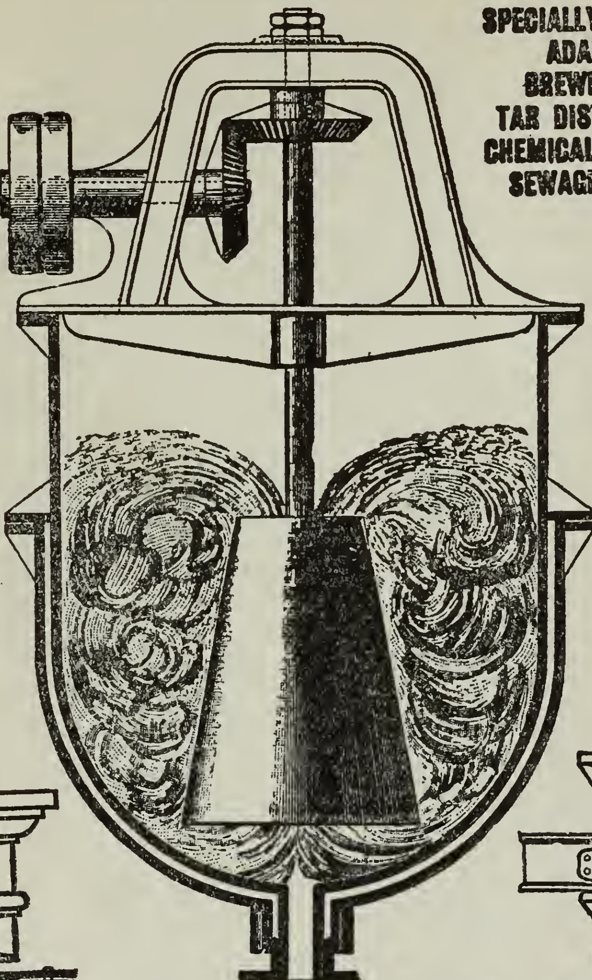
Engineers, Ironfounders, and Manufacturers of Machinery and Constructional Ironwork.

THE RAPID MIXER

BURT, BOULTON & HAYWOOD & E. R. GABBETT'S PATENT.

Telephone No. 2067.

SPECIALLY ADAPTED FOR BREWERIES, TAR DISTILLERS, CHEMICAL AND SEWAGE WORKS.



ROLLED JOISTS, ANGLES PLATES, and TEES, kept in stock.

RIVETTED GIRDERS and CASTINGS of every description made in London.

STEEL AND WROUGHT-IRON CONSTRUCTIONAL WORK.

H. YOUNG & CO., LD.

ECCLESTON IRON WORKS, PIMLICO, and
HAYLE FOUNDRY WHARF NINE ELMS, S.W.

Complainants' Exhibit Young advertisement B.
United States District Court - District of Montana
Minerals Separation Limited and another
vs.
James M. Hyde
London September 3. 1912 J. Phillips Crawley
Commissioner